POWER PLANT ENGINEERING

Established Over 32 Years

VOL. XXXII CHICAGO, DECEMBER 1, 1928 No. 23

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Contents of this Issue

	Page
Power Plant Improvements at the Franklin Sugar Refining Company. Illustrated	1240
Standard Vacuum Gage Readings Urged	1246
High-Pressure Steam in Industrial Plants. By E. R. Fish	1247
Coal Carbonization as a Prepared Fuels Source—I. By A. A. Potter and H. L. Solberg. Illustrated	1248
Handy Humidity Chart. By W. F. Schaphorst. Illustrated	1250
Refractories and Air Supply Affect Combustion. By H. H. Baumgartner. Illustrated	1251
Store Rooms for Power Plants. Illustrated	1253
Heat Saving in Industrial Plants by Insulation. By L. B. McMillan. Illustrated	1256
Diesel Engines as Power for Industrial Plants. By Edgar J. Kates. Illustrated	1258
Transformer Loading-Back Tests. By A. Naeter. Illustrated	1261
Electricity—What It Is and How It Acts. Illustrated	1263
Light in Industrial Plants Should Be Ample. By R. J. Malcomson. Illustrated	1266
Motor Drive Controls Paper Machine Accurately. By F. W. Buck. Illustrated	1268
Designing Pulverized Coal Ducts and Burners. Illustrated	1270
Heating and Ventilation of Industrial Plants. By Edward P. Rich. Illustrated	1271
Ore Finding by Electricity	1274
Adjustable Propeller Runners at Chippewa Falls. Illustrated	1275
Aiding Boiler Heat Absorption By B. W. Dennis	1278
Letters Direct from the Plant: Wired Baffles Do Not Warp. Dollars Loss from Air Leakage. Boiler Feed Made Continuous with Bypass. Undrained Water Causes Damage in Winter. Oil Engine Operation by Pyrometer. Pulley Alinement Indicator. Illustrated	1279
Questions and Answers: Brake Horsepower Calculation. Boiler Seam Defects Inspected by Slotting. Safe Working Pressure for Drum. Valve Gear Action and Setting. Cable Installation in Conduits. Illustrated	1282
Editorial Comment: An Engineer as President. Keeping Fit	1284
Brake for Bridge Drives of Cranes. Illustrated	1286
Pushing Pipe Underground with Jacks. Illustrated	1286
Van Stone and Cup Joints for Small Pipe. Illustrated	1287
Westinghouse Develops New Insulators. Illustrated	1287
Portable Pneumatic Riveter for Light Work. Illustrated.	1287
Duke Power Co. Constructs River Bend Station. Illustrated	1288
Chicago Apparel Mart to Install Power Plant. Illustrated	1288
Alabama Power Co. Builds New Gorgas Plant. Illustrated	1289
Death of Frederick Kent Copeland	1290
News Notes	1290
Catalog Notes	1291
Power Plant Construction News	1292

Published on the 1st and 15th of each Month by the
Technical Publishing Co., 53 West Jackson Blvd., Chicago
New York Office, 171 Madison Avenue

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

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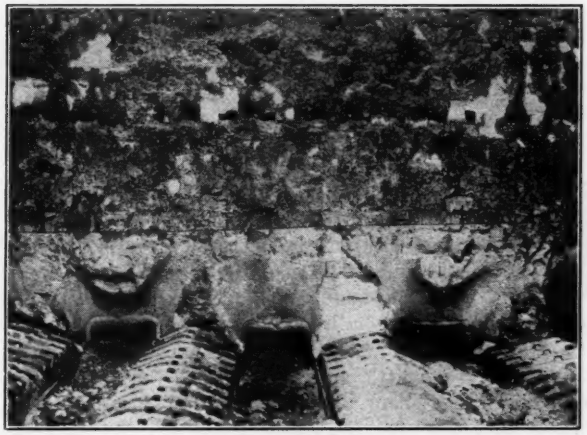
Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations.
Circulation of this issue 24,100



Etna in Miniature

ABOVE IS A VIEW which, with a little imagination, might be an airplane photograph of the slopes of Mt. Etna—lava streams flowing, groves for lemons and olives, dotted with Italian villas; all awaiting destruction by the oncoming fire devil. The corduroy roads and tunnels in the foreground are a bit hard to fit into the picture, so we hasten to state that it isn't a view of Mt. Etna.

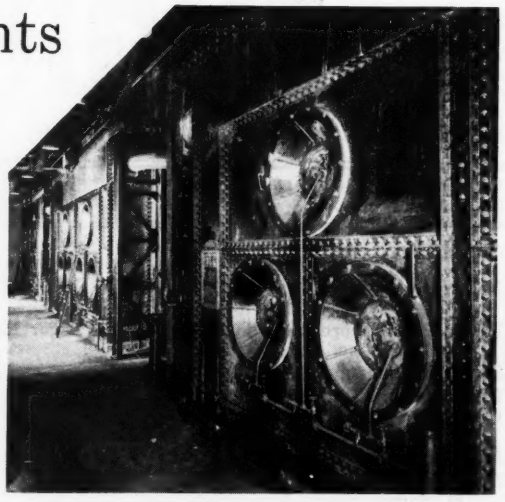
But it's the same process, only on a smaller scale. Intense heat, melting rocks to a flowing mass, so that the refractory furnace walls run downward to close air orifices and damage property. Fortunately, it is possible in the furnace to prevent or minimize the damage by proper construction. In the above view, which shows a combination of splits and 9-in. brick for over fire nozzles, the lava flow is confined to the lower part of the wall and only scattered patches of slag are formed around the nozzles.

Discussion of methods of prevention will be found in an article by Mr. Baumgartner in this issue.

MORE EFFECTIVE LIGHTING in industry is the watchword of the modern illumination engineer. Many engineers remember how, before the science of illumination was developed, the general practice in lighting industrial buildings was to hang a lamp from the ceiling wherever light was needed to perform the work. But the modern method of using general illumination for the entire room with spot lighting for individual work has been based on scientific studies of the requirements both of the process and of the worker. The contrast between the effects produced by the old haphazard method and the modern scientific method is startling. In this issue R. J. Malcolmson discusses these conditions and shows photographs of the "before and after" type.

Power Plant Improvements at the Franklin Sugar Refining Company

FIVE NEW BOILERS REPLACE FORTY-EIGHT, LEAVING SPACE FOR THE TURBINE - GENERATORS AND ANOTHER BOILER. REFINERY CONTINUES IN OPERATION DURING IMPROVEMENTS



OBSOLESCENCE is one feature of power plant design that is not predictable, either as to cost or time and the fact that some of the best equipment manufactured 10 or more years ago has become extravagant to operate under present day conditions must not be ignored. To maintain such equipment in operation is to carry a financial burden little appreciated until the advantages of modern machinery and practices are studied. Once installed, machinery cannot be discarded the moment something better has been brought out but managers who are on the alert will seize every opportunity to keep their plant up to its highest efficiency by modernizing practice, adding new devices here and there through the plant, replacing the less expensive obsolete equipment as the need indicates and then, when some outstanding developments have taken place in the principal units of the plant, making a general rehabilitation of the plant to fit the most modern conditions.

This, briefly stated, is the policy which has governed improvements at the Franklin Sugar Refining Co.'s power plant at Philadelphia, Pa., which has for several years past been undergoing extensive improvements that are making it a model in the industry it represents. To date, these developments have taken place principally in the boiler room but plans are under way to modernize the turbine room equipment as well and thus place the entire power plant in the ranks of the most efficient for its purpose.

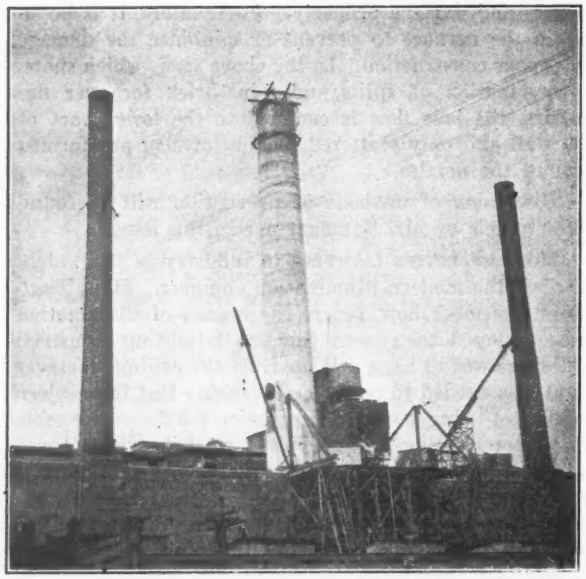


FIG. 1. REPLACEMENT OF THE BOILERS STARTED IN THE CENTER OF THE PLANT

NEW EQUIPMENT OCCUPIES OLD BOILER ROOM SPACE

This plant is located on the banks of the Delaware River where real estate is at a premium and economy of space plays a part in the selection of all equipment. For this reason, the problem of building a new plant was complicated by the fact that there was no vacant space available and the old plant must serve the needs of the refinery continuously during the transition period. These services consist of steam at several different pressures for power, processes and general heating purposes and electricity for power and lighting.

At present, the entire boiler plant has been replaced without interruption, though production was cut down to about one-half full capacity for about six months and when the new electric generating equipment has been installed the entire power plant, of considerably larger capacity than the former plant, will occupy the space previously taken up by the boilers alone and there will still be room for further expansion.

Before the changes took place, there were installed in the boiler plant 48 horizontal water-tube boilers, each of 250 hp. capacity. These were arranged on two floors, one directly above the other, set in batteries of two. Natural draft only was used with these boilers, the gases being cared for by four stacks, 240 ft. high and 10 ft. in diameter, 12 boilers feeding into each stack. As a rule, the boilers were operated at their rated capacity and at times 47 out of the entire 48 boilers were required to carry the load on the plant.

Of these boilers, 30 that operated at 108 lb. steam pressure were installed in 1889, six more were installed in 1891 and the last 12, that furnished steam at 150 lb. for running turbines, were installed in 1908. None of these boilers was provided with a superheater but all discharged their gases through economizers.

From the time these boilers were installed, they were

served by stokers though there had been a transition from the front feed inclined type to the dutch oven V type. As was the customary practice at the time these boilers were installed, the settings were low and it was difficult to get much more than the rated capacity from them, also internal feedwater treatment was used.

Five Boilers Replace Forty-eight

This equipment crowded the building space it occupied to the point where additional capacity was impossible under the existing arrangement and with a growing load, the solution of the problem pointed to the replacement of the entire boiler equipment with modern high capacity steam generating equipment. With this part of the rehabilitation program completed, the plant now has five Stirling boilers each having 10,210 sq. ft. of heating surface exclusive of the water walls which completely surround the combustion space with the exception of the area occupied by the boiler proper and a portion of the sides of the ash hopper which is air cooled. These five boilers burning pulverized coal do the work formerly done by the forty-eight 250-hp. boilers with plenty of reserve capacity to permit shutting down a unit for repairs under full load conditions in the refinery.

In beginning this work, the first step was to take down two stacks and remove the 24 boilers in the center of the boiler plant, replacing them with one stack and three new boilers. With these boilers in service, the east bank of 12 boilers with their stack was removed and replaced with No. 1 boiler, then the west bank of boilers was removed and the space used to accommodate No. 5 boiler. This work completed, space is left at the west end of the boiler house for another similar size unit and at the east end the extra space will eventually be occupied by three steam turbine generating units, their auxiliaries and the power plant switchboard. Thus the entire space occupied by the present generating units will be made available for refinery purposes.

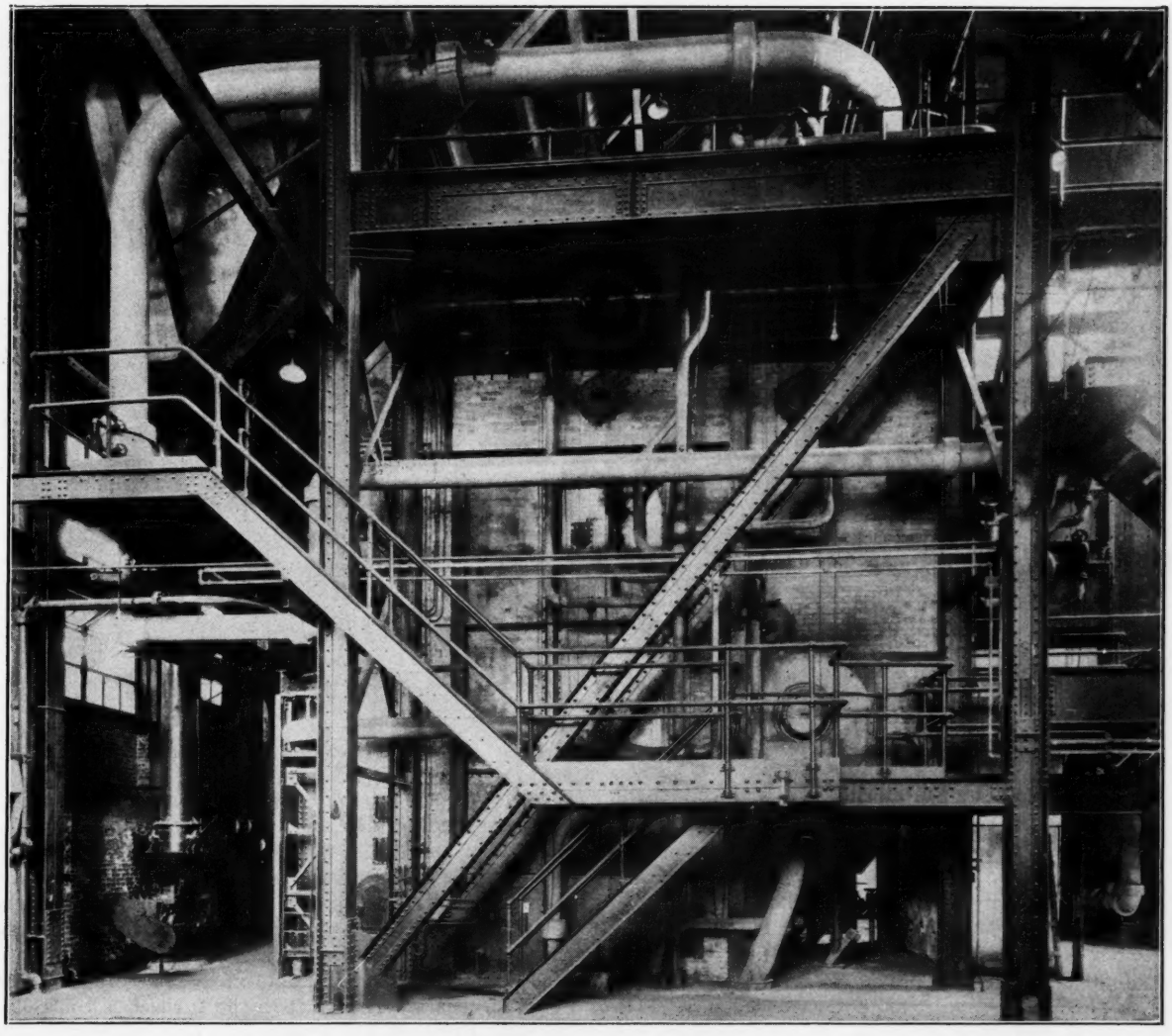


FIG. 2. SIDE VIEW OF BOILER NO. 5 LOOKING EAST SHOWS HOW STAIRS AND WALKWAYS HAVE MADE ALL PARTS OF BOILER ACCESSIBLE

No radical changes were made in the coal handling facilities but the pulverizing equipment is entirely new. Coal comes to the plant in barges and is unloaded by a

steam operated Jeffrey coal tower equipped with a 60-cu. ft. grab bucket capable of handling 100 t. per hr. This delivers to the feeder regulating the delivery to a Williams swing hammer crusher that reduces the size to ¾ in. From here, a 36-in. belt conveyor, 300 ft. long, takes the coal to the boiler house elevator that carries it to the top floor and delivers to a shuttle conveyor, equipped with magnetic separator, for distribution in a 2000-t. concrete bin which is divided into five compartments.

For each boiler, two unit pulverizers are installed. These are located in the basement and receive their supply through individual 20-in. pipes from the bins over

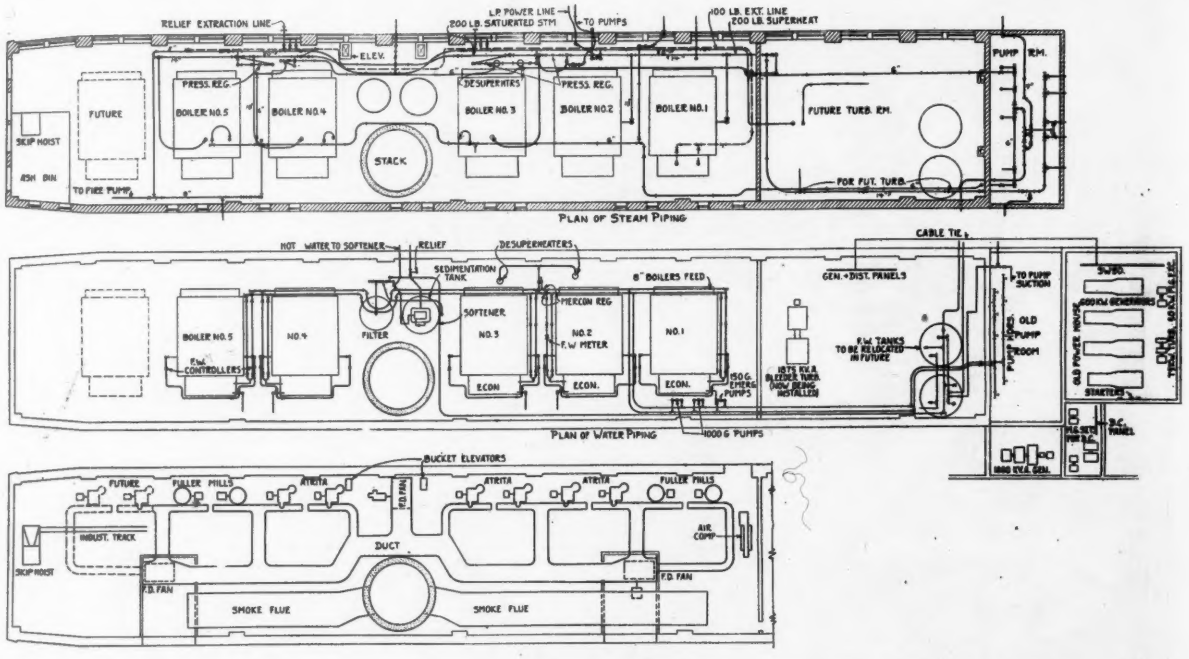


FIG. 3. PLANS OF THE PLANT SHOWING THE ARRANGEMENT OF EQUIPMENT, STEAM AND FEEDWATER PIPING

the firing aisle. Six of these pulverizers are No. 4 Riley Atritas. Of these, three are arranged for dual drive by a Westinghouse motor and a Terry steam turbine which exhausts at 7 lb. pressure. The other three Atritas are motor driven only. With these units, the feeders and fans are integral parts of the pulverizer.

For the remaining two boilers, four 36-in. Fuller Lehigh unit mills are provided. These are driven by Terry turbines taking steam at 200 lb. pressure 100 deg. superheat and exhausting into the low-pressure steam power line at 100 lb. back pressure. By this arrangement and the provision for an extraction turbine generator, the heat balance on the plant can be definitely controlled. Separate motors drive the feeders and fans serving the Fuller units.

Considerable experimenting was necessary before a coal having characteristics suitable to the installation was found, the abrasive quality of some coals making them difficult to pulverize and increasing maintenance costs on the pulverizers. Excellent results, however, are now being obtained with Pennsylvania coal having a general analysis on the dry basis of 27.16 per cent volatile, 63.08 per cent carbon, 9.76 per cent ash and a heat value of 14,144 B.t.u. per pound. This coal is pulverized to the point where 70 to 75 per cent goes through a 200-mesh screen.

Furnace Air Supply

Primary or carrier air is drawn through the hollow walls of the furnace ash hopper where it is heated on its way to the pulverizers, no other means of drying the coal being provided. Each pulverizer feeds three horizontal, turbulent, Peabody burners, six of which are provided for each boiler. A noteworthy feature of the installation is that the fuel piping is all inclosed, giving a neat appearance to the firing aisle. In order to secure an even distribution of heat in the furnace when the load is such as to require only one pulverizer, the fuel piping is arranged so that two alternate burners in the lower row and one in the upper are fed from each pulverizer. Three American Blower Co. Sirocco fans are provided to supply secondary air, two of these are driven by motors and the other by a steam turbine. The air supply to the furnace is regulated according to load conditions by means of a gate in the blast duct leading to the furnace. The draft in the furnace is controlled by the Engineer Co. system of balanced draft. The fires are lighted by means of an oil torch, oil being piped to the burners and a flexible connection being made to a portable torch when it is desired to light the fire. With water walls completely surrounding the furnace, as in this installation, fires may go out very quickly if the fuel supply is shut off for a short time. For this reason and in lieu of a connection with the local central station, an emergency electric generating set is provided for starting up from a complete shutdown, the operation of which will be described later.

Due to the water walls and the air-cooled sides of the ash hopper in the floor of the furnace, the ash falls to the bottom of the furnace in a flocculent mass where it remains until discharged into narrow gage industrial

cars that transport it to a Link-Belt skip hoist that elevates it to an ash bin whence the ash is loaded in railway cars for disposal.

Gases are drawn from the boilers through economizers by draft created by the stack which was built by the Rust Engineering Co., and is of concrete lined with firebrick. It is 330 ft. high, 27 ft. in diameter at the bottom and 15 ft. at the top and rests on a piling foundation, as does the entire power plant building.

Feedwater Treating System

Boiler feedwater comes originally from the Delaware River, being supplied to the plant through the

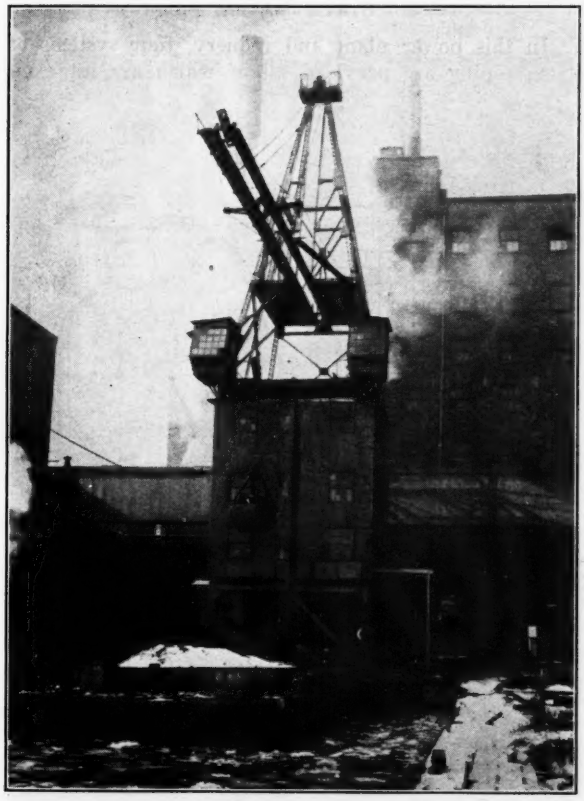


FIG. 4. COAL COMES TO THE PLANT IN BARGES AND IS UNLOADED BY MEANS OF A COAL TOWER

refinery's own intake mains and having a hardness varying from 34.2 to 88.5 parts per million. At the plant it is passed through a filter before going to the hot process Cochrane-Sorge water softener. This equipment consists of a softener capable of treating 16,000 gal. per hr. with which was furnished a deaerating heater capable of reducing the oxygen to practically zero. This treated water, which amounts to about 30 per cent of the boiler feed, is delivered through a filter to feedwater tanks where it meets the condensate returns from various industrial processes. These returns are sampled regularly and if they show the presence of an excessive amount of sugar, the returns are diverted until the condition has been corrected.

In ordinary operation, however, this condensate is only very slightly contaminated with sugar, which, upon heating in the boiler, is converted into organic acids which consume the sodium carbonate alkalinity, some

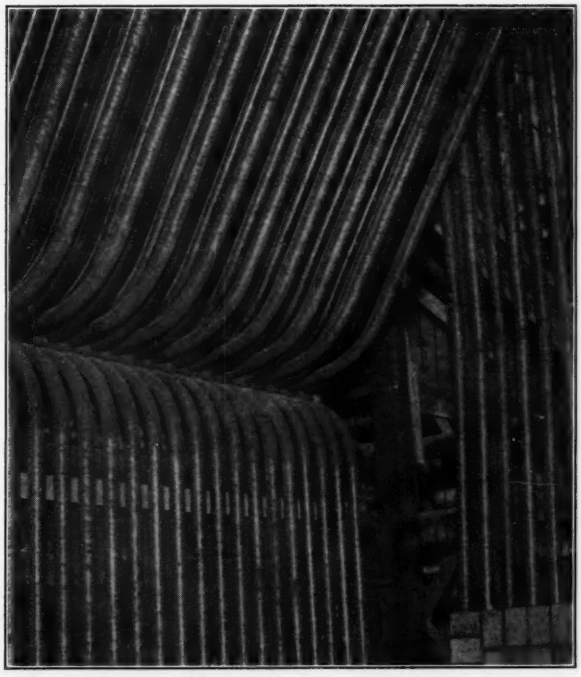


FIG. 5. VIEW IN UPPER PART OF FURNACE SHOWS BOILER, REAR WALL AND SIDE WALL TUBES DURING CONSTRUCTION

of which must necessarily concentrate in the boiler to prevent scale. For this reason, the make-up water is softened with a greater excess of sodium carbonate than is customarily required for water softening so that the excess sodium carbonate might neutralize the effect of the sugar introduced by the condensate. Tests are made of the water within the boiler and treatment of the make-up is based upon the results of these tests.

From this hot water tank, Worthington turbine driven centrifugal boiler feed pumps feed through the economizers to the boilers, a duplicate system of piping being provided. Steam for heating the water in the softener is taken from the low-pressure mains at 7 lb. pressure and as the water enters the economizers, it

FIG. 6. REAR AND SIDE WALLS OF FURNACE WITH BAILEY BLOCKS PARTLY IN PLACE

averages about 208 deg. In the economizers, it is heated to 300 deg. at which temperature it is fed to the boilers under the control of Stets feedwater regulators.

Inasmuch as the pressure in boilers Nos. 3, 4 and 5, which supply steam to the process, is usually less than in Nos. 1 and 2, which supply superheated steam to the turbines, Mercon regulators are placed in the feedwater piping to maintain a constant pressure differential. Boilers are opened for inspection and washing after evaporation of about 160,000,000 lb. of water which is equivalent to operating the boilers 75 days at an average of 275 per cent of the manufacturer's rating for 24 hr. per day continuously.

Features of the Boilers

As previously stated, five Stirling boilers are installed. Each of these has, in the boiler proper, 10,210 sq. ft. of heating surface. The front, back and sides of the furnaces are lined with water walls, Bailey blocks being used in two of the furnaces, and the tubes are placed on 6-in. centers. The depth of the furnaces is 15 ft. and the width 19 ft. The mud drums of the boilers are 10 ft. above the boiler room floor level which is 22 ft. above ground level.

All the boilers are provided with economizers of 6225 sq. ft. heating surface each, the ratio to the boiler heating surface being 0.6 to 1. These are Sturtevant steel tube economizers, lead coated both inside and outside. Tube dusting of the boilers and economizers is accomplished by means of Diamond soot blowers.

All of the boilers are designed for 250 lb. pressure, two of them being equipped with Foster superheaters and Tracyfiers. These units operate at 200 lb. pressure and 100 deg. superheat. Boilers Nos. 3, 4 and 5, however, are not provided with superheaters but operate at 200 lb. delivering saturated steam to a separate header. The piping is such, however, as to allow an interchange of steam between headers under certain conditions of operation. On occasions these boilers have been operated at 300 per cent of rating for 24 hr. but in ordinary operation the usual load is 225 to 250 per cent of rating. Each of the boilers is equipped with a Bailey boiler meter and steam to the various departments is separately measured by Republic flow meters. Schaeffer & Budenberg gages and Bristol recording instruments are installed throughout the boiler room.

Steam Service

In this power plant and refinery, four systems of steam piping are provided all of which are interconnected through regulating valves and desuperheaters so that as long as either of the superheat boilers is in service, all the various services can be met. All boilers generate steam at 200 lb. pressure. Boilers Nos. 1 and 2 superheat the steam 100 deg. F. while boilers Nos. 3, 4 and 5 deliver saturated steam. Superheated steam is needed for driving the turbine generators and the turbine driven feedwater pumps and coal pulverizers. Saturated steam at 200 lb. pressure, in what is known as the independent power line, is used for driving the old plant auxiliaries and certain other units about the refinery. A 100-lb. pressure line is fed through regulating valves from the 200 lb. saturated steam line supplemented by steam from the pulverizer turbines. This line supplies steam to a low-pressure power line and, through regulating valves, furnishes steam for

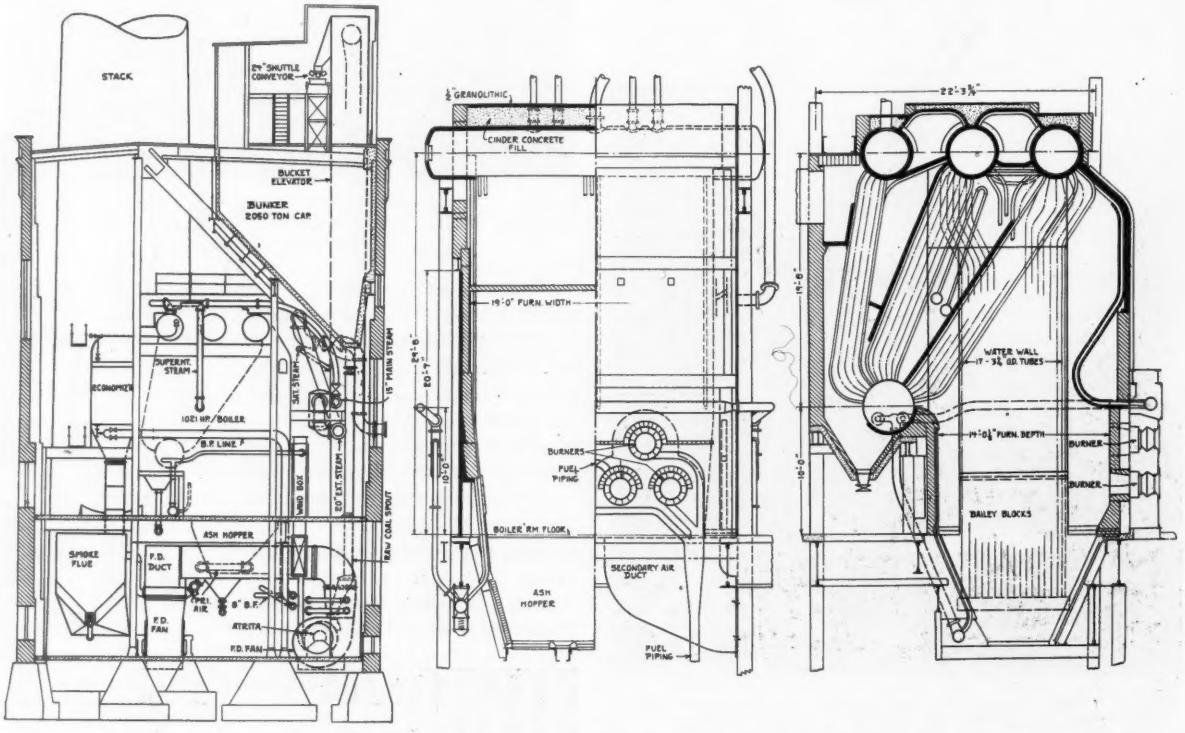


FIG. 7. ELEVATIONS OF A BOILER SHOWING ARRANGEMENT OF PULVERIZING EQUIPMENT, BURNERS AND HEAT ABSORBING TUBES

several process services. The fourth system is carried at 7 lb. pressure and takes exhaust steam from the turbines and all auxiliaries supplemented, when necessary, by steam from the 100 lb. pressure line.

In regular operation, boilers Nos. 1 and 2 supply all the superheated steam needed and at times when the process steam load is heavy they help out by feeding through an Atwood & Morrill regulating valve to the 200-lb. saturated steam line, thence through another regulating valve, desuperheater and separator to the low-pressure power line. This blow-over from the superheated to the saturated line takes place automatically when, due to the heavy load, the pressure in boilers Nos. 3, 4 and 5 drops to a few pounds below that in boilers Nos. 1 and 2. Conversely, the saturated steam

FIG. 8. FEEDERS AND CONTROL EQUIPMENT FOR THE PULVERIZERS ARE LOCATED ON THE BOILER ROOM FLOOR DIRECTLY ACROSS THE AISLE FROM THE BURNERS

blows over to the superheated line if for any reason, such as suddenly closing several of the process steam lines, the steam pressure rises above that in the superheated line. Safety valves, of course, take care of excess pressure in the boilers and relief valves are provided on the 100-lb. extraction line to prevent an over pressure. Provision is also made to cut off the pan line by means of a regulating valve in case the pressure in the extraction line falls below a predetermined pressure and thus give the boilers an opportunity to adjust themselves to the load. Mason regulators are used for tying in between these systems and Elliott desuperheaters convert the superheated steam drawn off for process purposes into saturated steam.

Electric Power Service

At present the electric generating equipment consists of four 600-kv.a. and one 1000-kv.a. Westinghouse

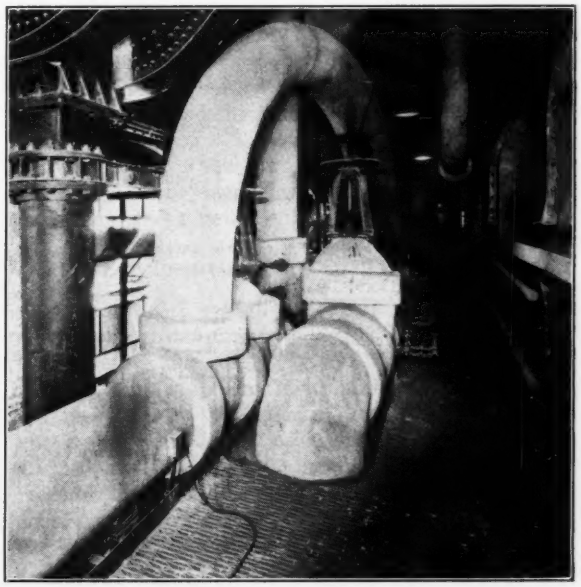


FIG. 9. WALKWAY OVER FIRING AISLE SHOWING 20-IN., 100-LB. STEAM PRESSURE LINE

turbine generators delivering three-phase, 60-cycle current at 440-v. These are located in the old turbine room beyond the east wall of the boiler house. Plans are under way, however, to replace these machines by new units which will occupy space vacated by some of the boilers in the east end of the boiler house. During this reconstruction work, the voltage of power equipment throughout the refinery has been increased from 220 to 440 v. and a new switchboard has been installed in what will be the turbine room which, during the transition, is tied in with the old switchboard. As new generators are installed, new panels will be added to the switchboard.

Extraction Turbine to be Installed

At present a 1500-kw. Westinghouse turbine generating unit is under order. This is of the extraction type receiving steam at 200 lb. pressure and 100 deg. superheat with a bleeder connection that supplies steam to the process lines at 100 lb. pressure and the exhaust is into another process line at 7 lb. back pressure. When this unit is placed in operation, the operating force will be able to control the heat and power load so as to use all the exhaust steam for heating or process purposes so that no heat waste will occur.

Due to the fact that the plant has no outside electrical connection, an emergency generating set has been installed. This consists of a Sterling gasoline engine direct connected to a Westinghouse generator of 50 kv.a. capacity furnishing three-phase current at 440-v.

In case power from the steam plant should fail for any reason, this set may be started instantaneously by means of a push button and will furnish power for operating a Kinney oil pump which will supply oil to the Peabody pulverized fuel burners for steam generation. The set also furnishes power to a small emergency boiler feed pump and takes care of the lighting in the boiler house. Thus even with all fires completely dead, the plant can be started quickly.

As operated at present, the plant generates about 8,500,000 lb. of steam in 24 hr. and employs five men per shift in the boiler room, whereas in the old boiler plant the operating force consisted of 15 to 18 men

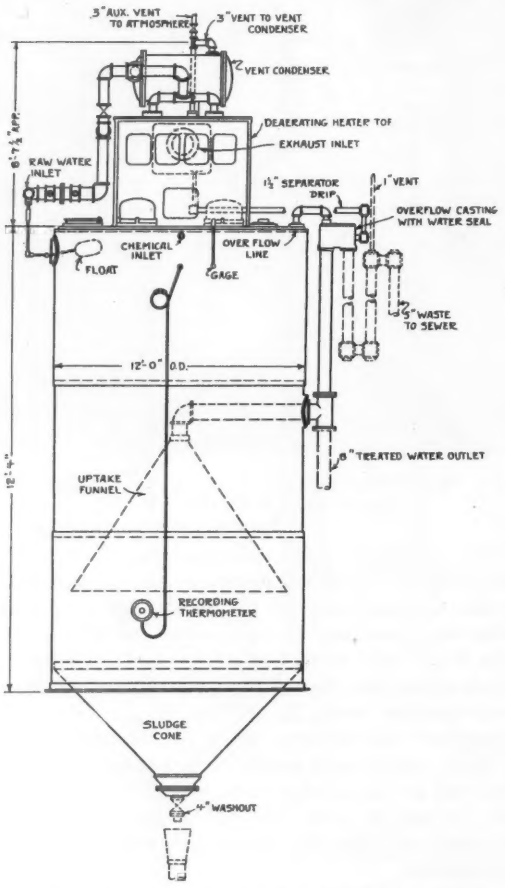


FIG. 10. CROSS SECTION OF WATER SOFTENER

per shift. In normal operation 21,000,000 lb. of raw sugar are refined per week.

This entire reconstruction job including engineering design and construction was carried through by Stone & Webster, Inc., of Boston, in collaboration with the engineering organization of the Franklin Sugar Refining Co.

SALES OF MECHANICAL STOKERS for August as reported to the Department of Commerce by the 11 leading manufacturers in the industry reached a total of 162 stokers installed under 51,572 hp. of boilers. Of this number, 57 stokers were installed under 7895 hp. of fire-tube boilers and 105 stokers were installed under 43,677 hp. of water-tube boilers.

Standard Vacuum Gage Readings Urged

WHEN THE vacuum or back pressure of a condenser, engine or turbine is given, it is called the rated vacuum or rated back pressure of the machine. This implies also a standard barometric pressure which may or may not be given.

When the rated vacuum, back pressure or standard barometric pressure is referred to in inches of mercury, such as, "28 in. vacuum with 29.92 in. barometer," or, "28 in. with 30 in. barometer," it is understood that the figures are as read from the mercury column after a reduction to 32 deg. F.

When a test is being run, the actual barometric pressure must be found and corrected. The difference between this value and the standard barometric pressure, when corrected, must be applied to the rated vacuum or back pressure to give the value which approaches as nearly as possible the actual value for the rated back pressure.

A standard barometric pressure which has occasionally been used is one corresponding to some average room temperature between 60 and 70 deg. F. This standard requires the use of a value for the barometric pressure different from that used by the weather bureau and does not take account of the possibility that the barometer and mercury gage might be in different rooms under different temperature conditions.

Another standard barometric pressure which is described in some text books is based on the assumption that when the term, "30 in. vacuum" is used, the standard atmospheric pressure of 29.92 in. of mercury column at 32 deg. F. is meant. Accordingly, on this basis, the given value of 30 in. is understood to be 30 in. at some particular temperature which, when corrected to 32 deg. F., will give 29.92 in. of mercury column. This temperature has been worked out and found to be about 58 deg. F.

GRAVITY CORRECTION MUST NOT BE NEGLECTED

In this reduction of the value of 30 in. for standard condition, the gravity correction has been omitted. For gravity correction such as that which would correspond to 40 deg. of latitude, the temperature at which an actual 30-in. column must be in order to correspond with a 29.92 in. of mercury at standard conditions is about 53 deg. F. The use of any such standard is objectionable for the reason that it requires reduction of the mercury column measurement so that it corresponds to a temperature different from the temperature used in scientific work and also because it requires the use of a corrected barometric pressure varying from the value used by the weather bureau.

Corrections and detailed directions for making correct measurements are included in a new chapter of the A. S. M. E. Code on Instruments and Apparatus which has just been issued in preliminary form.

RHINELANDER PAPER CO., Rhinelander, Wis., is reported to be planning the construction of a power house for a projected pulp and paper mill in the vicinity of Seattle, Wash., to cost about $1,500,000. William E. Eibel is general manager.

High-Pressure Steam in Industrial Plants

PRESSURES OF 300 LB. AND OVER ARE BECOMING COMMON AND PRESENT NO DIFFICULTIES. BY E. R. FISH*

PRESENT DAY concepts of what is high steam pressure are quite different from those of ten or fifteen years ago when 250 lb. per sq. in. was extraordinary. The rapid increase in the demand for higher pressures has raised this figure to the point where those quite commonly used now range up to 500 or 600 lb. For convenience of definition, we may designate pressures up to 300 lb. as moderate, from 300 to 600 lb. as high and over 600 lb. as very high.

While the use of the range up to 300 lb. still includes the great majority of plants, the range of from 300 to 600 lb. is becoming more and more common. For the present, at least, the use of very high pressures of around 1200 to 1800 lb. per sq. in. will be confined mainly to large central stations where prime movers adapted to these pressures are used as reducing valves for the lower pressure turbines, thereby justifying high investments and the highest class of adequate supervision. There are, however, now several industrial plants using such pressures where conditions have made it advisable.

REHEAT NEEDED FOR OVER 500 LB.

It is necessary, of course, to superheat steam at all the higher pressures but, when about 500 lb. is reached, it becomes essential to employ reheating in order to avoid wet steam in the lower expansions in the turbine. This introduces certain plant complications both as to equipment and operation. Therefore, when resort must be made to reheating, it is advisable to go to the very high pressures and thus secure the greater benefit resulting from the added expansions, with relatively small extra cost.

Boiler plant accessories necessary for the generation, transmission and utilization of high-pressure steam have been so perfected that these may be readily obtained at reasonable prices, hence the cost of adopting this modern practice is not prohibitive.

The value to the industrial plant of high-pressure steam as above defined lies in the practicability of the economic generation of its own electric current and still to have steam available at pressures suited to any particular process work and for heating purposes, whether at atmospheric or at moderately higher pressure. From turbine generators, steam may be bled at such stages as is needed for special purposes. Complete expansion results in steam at about atmospheric pressure, but still having available the latent heat.

PROCESS STEAM JUSTIFIES ISOLATED GENERATION OF POWER

Generally speaking, when steam in any quantity is needed, for any purpose whatsoever, during a large part of the year, it will almost inevitably be found that the boiler house costs in the industrial plant will justify isolated generation when compared with the purchase of central station current.

Such plants seldom justify condensing apparatus, although the price of coal and other considerations may make it advisable to have condensing equipment available for use when there is steam to waste.

Expected performance of a steam plant can now be predicted within narrow limits of error and any engineer versed in power plant practice can so analyze conditions through the use of steam and power consumption data, heat balances, cost of equipment and all the overhead charges as to vary but a small percentage from the actual results found after the plant has been put in operation.

Rehabilitation or replacement of obsolete steam generating plants and the inclusion of its own power plant in the case of new industries, is becoming more and more common. Plant owners and designers are taking advantage of the economical steam generating and steam using equipment now available.

HIGH-PRESSURE OPERATION NO LONGER A PROBLEM

Operation of a high-pressure steam plant is not a complicated problem nor a source of apprehension to the operators, due to the variety of perfected apparatus, fittings, and equipment now obtainable. Furthermore the development of indicating recording and control apparatus is such that economical operation can be assured and maintained indefinitely and the results recorded in such a manner that those in responsible charge may have positive evidence from day to day of the operating characteristics.

Fuel burning equipment has also been highly developed so that sustained economical operation is assured, even when using the lower grades and, consequently, cheaper fuels available in any vicinity.

Labor saving devices for the preparation and handling of the fuel, refuse disposal and the like may be installed to whatever extent the conditions justify, the consideration of which is part of the general problem of the design.

In modern plants, the rate of evaporation is frequently two to five times that considered possible a relatively few years ago, thus the cost and size as compared to an installation of the older type is greatly reduced.

All these various items of design, equipment and control are inevitably associated to a greater or lesser extent with the use of high pressures. The answer to the question as to whether or not a high pressure industrial plant can be justified economically may almost indubitably be answered in the affirmative.

*Manager, Steam Generation Division of the Combustion Engineering Corporation, New York.

New Unit Adds 30,000 Kw. to Saginaw River

IN THE ARTICLE under the above title, by J. W. L. Harris, beginning on page 1098 of our October 15 issue, the footnote at the bottom of that page should read "Engineering Department, Commonwealth Power Corp." as Mr. Harris is a member of that organization and not of Consumers Power Co.

ONE THORN of experience is worth a whole wilderness of warning.—Lowell.

Coal Carbonization as Prepared Fuels Source--I*

Coke, Gas and By-Product Formation at High and Low Temperatures. By A. A. Potter† and H. L. Solberg††

BY CARBONIZATION of coal is meant the heating of coal in the absence of air to a temperature sufficiently high to drive off most of the volatile matter, thus leaving a residue which consists of fixed carbon, ash and a small part of the original volatile matter of the coal. The principal products obtained by such treatment are as follows:

(1) A strong, coherent residue of carbon and ash, known as coke, which is used in blast furnaces and foundries, or a weak friable carbon deposit which is a smokeless fuel.

(2) Coal gas.

(3) Tars and oils which are of considerable value in chemical industries and as substitutes for petroleum derivatives.

(4) Nitrogen compounds such as ammonia sulphate which are valuable as fertilizers.

Quantities of these various products which are obtained from one ton of coal depend upon the kind of coal, the method of carbonizing the coal and the equipment available for recovering some of the by-products.

The importance of the coal carbonizing industry is evidenced by the fact that about 15 per cent of all the coal used in the United States is carbonized, while in certain of the European countries, even a larger per cent of the coal used is carbonized. The principal products are either city gas or coke for metallurgical purposes. In the manufacture of artificial gas, little attention has been given in the past to the quality of the coke produced. Similarly, if metallurgical coke was the final product, the carbonizing equipment was operated to produce a good coke with little regard for the quality of the gas.

In recent years, there has been a growing tendency to combine the two processes in the modern by-product coke oven which is operated to produce both coke and gas of good quality and to recover the valuable by-products such as tar and ammonia. Power plant engineers are vitally interested in the problems of carbonizing coal because of the prospect of combining the power plant of the future with the gas plant, thereby recovering the gas and the valuable by-products of the coal and burning the residue for the generation of steam. Several experimental installations of this type have been made recently. Should these prove successful, they will, undoubtedly, have a great influence upon the central station power plant and upon the artificial gas industry.

The Behavior of Coal During Carbonization

When a coal suitable for the manufacture of coke is heated in the absence of air in a closed chamber or retort, carbon dioxide, carbon monoxide and water vapor are driven off at temperatures of about 400 deg. F. The coal softens or fuses and becomes pasty or semi-fluid at temperatures of from 570 to 750 deg. F. This is followed by a rapid evolution of gases and a gradual hardening of the carbon residue. Most of the gases have been distilled from the coal at temperatures of from 700 to 900 deg. F. and most of the tars and heavy oils are evolved at temperatures of less than 1100 deg. F. The carbon residue hardens and shrinks to form a hard, porous, coherent mass of fixed carbon and ash with some volatile matter and is known commercially as coke.

Many coals, when heated in the absence of air in a retort, instead of fusing to form hard lumps of coke, disintegrate into a carbon residue having a loose, granular structure like sand. The formation of lumps depends upon the presence of a bonding material which will cement together the carbon residue of the coal. If this bonding material is present in excessive amounts, it interferes with the liberation of the gas bubbles, causes excessive swelling and leaves a light, porous coke. If insufficient in quantity, the coal does not fuse or melt but merely disintegrates and leaves a non-coherent residue. If a coal has an excessive amount of this binding material, it is necessary to mix with it a poorly coking coal in order to produce a coke of good quality.

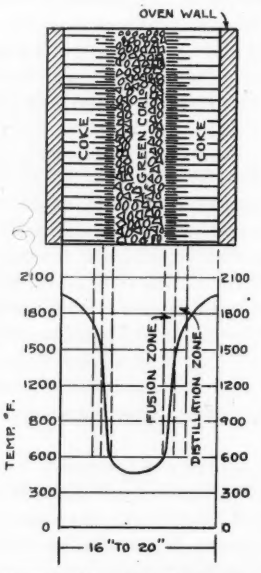


FIG. 1. CARBONIZATION OF COAL IN A COKE OVEN

Mechanism of Coke Formation

Figure 1 shows, diagrammatically, the behavior of a coal when placed in a retort, whose wall temperature is about 2000 deg. F. The coal in contact with the hot surfaces of the retort is heated to the temperature at which it fuses. The fusion zone travels from the walls of the retort inward at the rate of about ½ in. per hour. This zone is practically gas tight and offers considerable resistance to the flow of heat, consequently, the

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††Assistant Professor of Mechanical Engineering, Purdue University.

green coal within the fusion zone is relatively cool. Most of the volatile matter is driven from the coal at temperatures above the temperature at which fusion occurs, a carbon residue or coke remaining.

As the gases and tarry vapors are distilled on the hot side of the fusion zone, they flow outward through the cracks in the coke and upward along the walls of the retort to the top where they are collected in pipes. In flowing outward through the hot coke and coming into direct contact with the walls of the retort, the gases are heated to a temperature sufficiently high to bring about thermal decomposition or cracking, the molecular structure of the gases is broken down and a carbon deposit is left on the coke, which imparts to it the characteristic silvery appearance of good coke. This cracking process which occurs when the gases are heated to more than about 1100 deg. F. causes a reduction in the heating value of the tars which are distilled from the coal.

As a result, the by-products which are recovered from the gases leaving the retort are considerably different from those which would be obtained if the gases were not subjected to temperatures sufficiently high to cause decomposition or destructive distillation. At present, all commercially successful processes for the manufacture of coke or gas employ retort temperatures which are high enough to cause cracking of the gases and tarry vapors. A great deal of effort and money has been expended in the last few years in trying to develop a low-temperature process of carbonizing coal, i. e., using maximum retort temperatures which are low enough to avoid thermal decomposition of the gases distilled from the coal. The difficulties involved in developing such a process will be discussed later.

Properties of Coke

About 50,000,000 t. of coal are carbonized annually to produce coke for blast furnaces and foundries. Metallurgical coke has an ash content of from 8 to 16 per cent but a coke having an ash content of less than 10 per cent is preferred. The sulphur content should be less than one per cent and not over one and one-half per cent. The coke must have sufficient strength to support the blast furnace charge. It should be not less than ¾ in. in size and in many instances, only coke over 1¼ in. in size is used, if the smaller size can be disposed of at a fair price. As a result, some of the smaller sizes may be sold for domestic consumption. Special stokers have been developed within the past few years for burning the finer sizes which pass a ½-in. square opening and are known as "coke breeze."

Carbonization Processes

Carbonization processes are classified as high temperature and low temperature, 1100 deg. F. seeming to be the dividing line between the two processes. In the high-temperature carbonization process, metallurgical coke and large quantities of low-heating-value gas are the main objections. The low-temperature carbonization process yields more tar, less gas (of high heating value) and a coke which is suitable as a substitute for anthracite coal for domestic heating.

When use is made of the high temperature carbonization process, the quality of the coke by this process is generally of minor consideration. The retorts used are about 26 in. wide by 15 in. high. If fired from one end and closed at the other, they are about 10 ft. long. If fired from both ends, they are about 20 ft. in length. A gas offtake is provided for each retort and the gas is collected in a main above the setting. After being charged with a high-volatile coal, they are sealed to prevent the entrance of air. Heating is accomplished by passing the hot products of combustion of producer gas upward around the retorts, from 15 to 25 per cent of the coke produced in the retorts being fired into the producer to make producer gas which is conducted through the CO flue and burns with secondary air under the retorts.

Waste heat in the hot gases leaving the retorts is utilized in recuperators or regenerators to heat the primary air supplied to the producer or the secondary air required for the combustion of the producer gas or both. In the recuperator, the hot waste gases are conducted through flues and the cold air is drawn through the flues, thereby absorbing heat from the gases through the walls of the flues. The regenerator consists of two sets of flues. Waste gases pass out through one while the cold air is drawn in through the other. After a period of about 30 min., the dampers are reversed and the cold air passes in through the flue which has been heated by the hot waste gases while the gases pass out through the flue which has been cooled by the air. In this manner, heat is alternately stored in the flue by the hot gases and then absorbed by the cold air.

Time required to carbonize a charge of coal varies from 8 to 12 hr. From 11,000 to 12,000 cu. ft. of gas are produced from a ton of coal, the heating value of the gas being from 500 to 550 B.t.u. per cubic foot. After being cleaned and washed to remove the tars and ammonia compounds, the gas is distributed for general domestic and industrial use. The coke produced is of poor quality. It is weak and small in size so that it is unsuitable for metallurgical purposes. Some of it is fired to furnish the heat required to operate the process. Much of it is used as fuel in water gas sets. The rest is sold for domestic consumption.

Beehive Coking

Beehive coke ovens, operated solely to produce coke, all other products being wasted, are 12 or 13 ft. in diameter and 7 or 8 ft. high. The charge, consisting of 5 or 6 tons of coal, is introduced into the oven through a charging door in the top. After the charge has been leveled through a side door to a depth of about 2 ft., this door is partially closed to prevent the admission of too much air. The heat retained in the brick work from the preceding charge is sufficient to heat the coal to a temperature such that the volatile gases are distilled from it and burn with a limited amount of air so as to maintain the temperature in the oven.

At the end of two or three days, the volatile matter has been expelled and the coke remains on the hearth. This is quenched with water and withdrawn to make ready for the next charge. The process is extremely wasteful since the only product is coke and even some of this is burned by the air which is admitted to the oven.

Development of the by-product coke oven has been to produce a satisfactory metallurgical coke and, at the

same time, to conserve the coal gas, the tars and the nitrogen compounds which can be recovered from the gas by scrubbing and washing. The ovens are rectangular in cross section, from 30 to 35 ft. long, 8 or 10 ft. deep and from 16 to 20 in. wide. They are arranged side by side with a space between retorts through which the hot gases are circulated for heating the walls of the retort to a temperature of from 1900 to 2200 deg. F. The retorts are charged mechanically and at the end of the coking period, which varies from 14 to 18 hr., the coke is expelled by a mechanical pusher.

Heat required to operate the ovens is obtained by burning about 40 per cent of the gas produced from

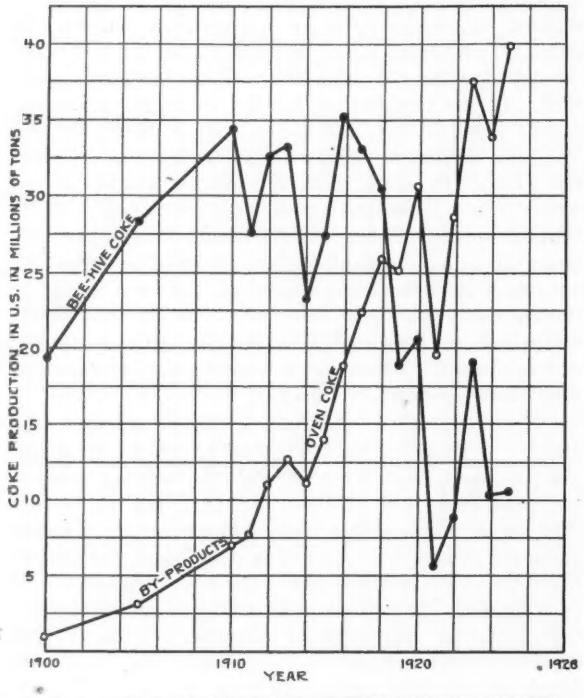


FIG. 2. COKE PRODUCTION IN THE UNITED STATES, 1910 TO 1925

the coal, the remainder of the gas, or about 6000 cu. ft. per ton of coal, being available for distribution, after being treated in an elaborate system of scrubbers to remove the valuable by-products. Approximately 4 gal. of benzol, 10 gal. of tar and 25 lb. of ammonium sulphate are thus recovered per ton of coal. The benzol may be blended with gasoline to produce an excellent fuel for automobile engines. The lighter fractions of the tars are invaluable in chemical industries such as the manufacture of high explosives and dye-stuffs, while the heavier fractions are used for road construction. Ammonium sulphate is used as a fertilizer.

Because of the mechanical equipment required for its operation, the by-product coke oven is applicable only to installations of large size. Although the construction of such a plant requires a large outlay of money, it is rapidly superseding the beehive oven, as shown in Fig. 2, the annual coke production in the United States by each type of equipment, data being taken from Mineral Resources of the U. S., published by the U. S. Geological Survey.

(To be continued)

Handy Humidity Chart

By W. F. Schaphorst

THIS SIMPLE chart gives the relative humidity instantly without the use of tables and without any figuring.

It is based on a formula recently derived by the U. S. Bureau of Standards. The formula, however, involves logarithms, and as logarithms are not easy for anybody to use, the writer developed this chart which anybody can use.

Simply run a straight line through the dry bulb temperature, Column A, and the wet bulb temperature, Column B, and the relative humidity is instantly given at the intersection with Column C. Or, just stretch a black thread across the chart.

For example, if the dry bulb temperature is 100 deg. F. and the wet bulb temperature is 85 deg. F., what is the relative humidity? This chart is quicker than tables or figures.

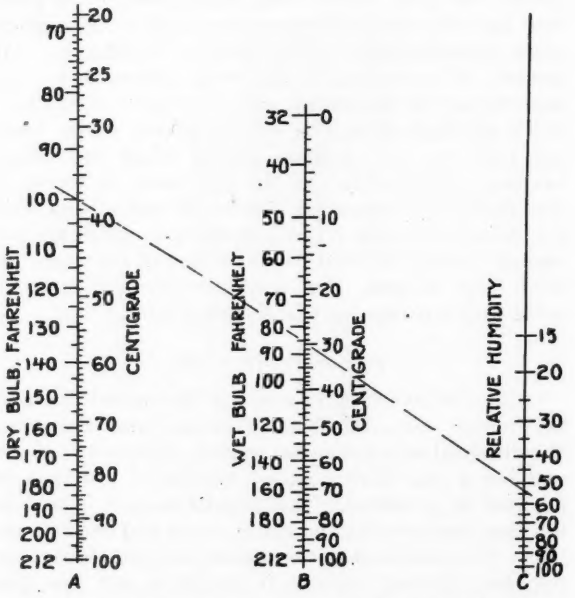


CHART FOR DETERMINATION OF RELATIVE HUMIDITY

Answer. The dotted line drawn across the chart shows how it is done and shows that the relative humidity, column C, is 54 per cent. Could anything be simpler?

Another advantage of this chart is that it gives temperatures in both Fahrenheit and Centigrade whereas the formula is Centigrade. Very few are familiar with the Centigrade scale.

For those who would prefer to use logarithms, here is the rule on which this chart is based:

(a) To the wet bulb temperature in deg C. add 20;
(b) To the dry bulb temperature in deg. C. add 20;
(c) Divide (a) by (b);
(d) Raise the quotient to the 4.3 power.

The result is the relative humidity.

This rule has been tested out by the Bureau for dry bulb temperatures between 20 and 100 deg. C.

Refractories and Air Supply Affect Combustion

DRIP LEDGE FOR SLAG AND AIR NOZZLES FOR SECONDARY AIR LENGTHEN LIFE OF FURNACE AND REDUCE COMBUSTION LOSS. BY H. H. BAUMGARTNER

TO SUPPLY sufficient air for complete combustion through that section of the fuel bed where distillation of gases and ignition is proceeding is impossible. This emphatic statement, made and demonstrated by the Bureau of Mines years ago, has long been recognized by the larger power companies and provision has been made, in most plants of large capacity, to supply this deficiency of air (oxygen) by the admission of secondary air over the fire in a proper location and manner. Not only is it impossible to supply sufficient air through the fuel bed, in the ignition and distillation zones, but this statement applies likewise to heavy fuel beds of coke.

Increasing use under small boilers of stokers with their characteristic ability to carry high ratings, has resulted in discovering the same difficulty, correcting the condition by experimental means and ultimately perfecting the experimental design.

HYDROGEN HEAT LOSS WITH CO

Our old reliable indicator of incomplete combustion —CO or carbon monoxide in the flue gases—is still the unimpeachable authority; but a small percentage of CO may be too hastily considered as but a small loss (10,160 B.t.u. per pound) due to the additional heat that would have resulted had it burned to CO_2. This is not the entire story. Tests made by the Commonwealth Edison Co., one of the few companies making hydrogen determinations, disclosed the presence of three per cent hydrogen along with six per cent carbon monoxide when burning Illinois coal on a chain-grate stoker. Complete details of these tests were given in the N. E. L. A. report on Stokers and Furnaces of 1925-26, pages 7 to 19. The loss due to unconsumed hydrogen can be appreciated when it is recalled that its heating value (lower or net) is 52,920 B.t.u. per pound.

INSUFFICIENT AIR INJURES FURNACE WALLS

Another unfavorable effect of insufficient over-fire air is the deterioration of the lining of the furnace. Among the greatest enemies of refractories are active fluxes which, being present in coal largely as unsatisfied compounds such as iron oxide, are most active in a reducing atmosphere. This may well be the explanation for the unduly rapid slagging and eroding of some front walls of underfeed stokers; a condition that is aggravated by heavy fuel beds and a sudden introduction of a large volume of green coal for the purpose of picking up the peak loads which, although anticipated, were not properly prepared for. The policy of saving coal during the "grave-yard" shift by letting the fuel bed get out of proper condition to pick up the morning peak, is most expensive. Preparing boilers for peak loads, with special attention to the operation of these boilers during the last half of the night shift, is worthy of a separate article and should receive the attention it justly deserves.

In designing stokers, to keep pace with the demand for higher ratings and larger capacities, the rams of certain underfeed stokers were increased in size until they were found to encroach on the area available for tuyeres. In one case, the writer overcame this condition to a large extent, by suggesting the addition of air-admitting members under the main tuyeres. Certain other types of stokers maintain a heavy fuel bed along the forward section of the side walls and, in this case,

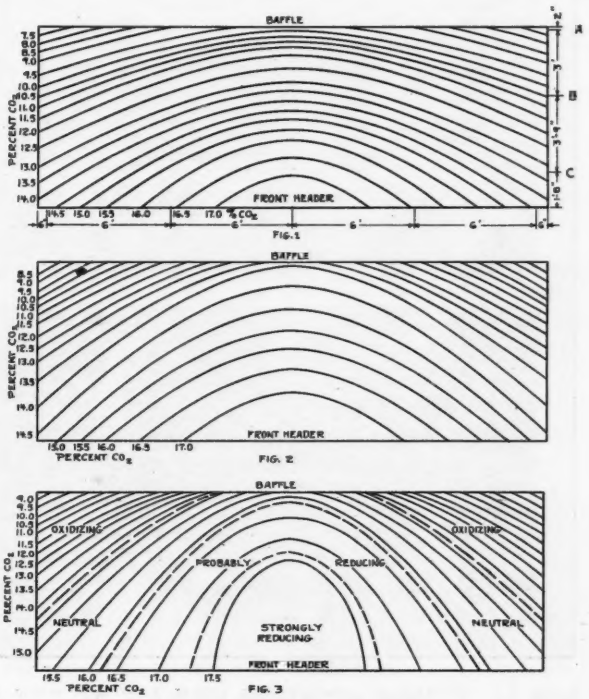


FIG. 1. FLUE GAS STRATIFICATION IN FIRST PASS OVER FIRST ROW OF TUBES ABOVE SUPERHEATER. HORIZONTAL PLANE AT 165 PER CENT OF RATING

FIG. 2. STRATIFICATION IN SAME LOCATION AT 225 PER CENT OF RATING

FIG. 3. STRATIFICATION OF GASES AT 275 PER CENT OF RATING

the admission of air at that point has proved highly advantageous from the standpoint of refractory maintenance. With the exceptions mentioned, the following principles illustrate the general trend of methods which have been established, experimentally, as beneficial to the operation of the furnaces.

SUPPLY OF AUXILIARY AIR

1. Air-cooling of refractories, without further increasing the excess air along side and bridge walls.

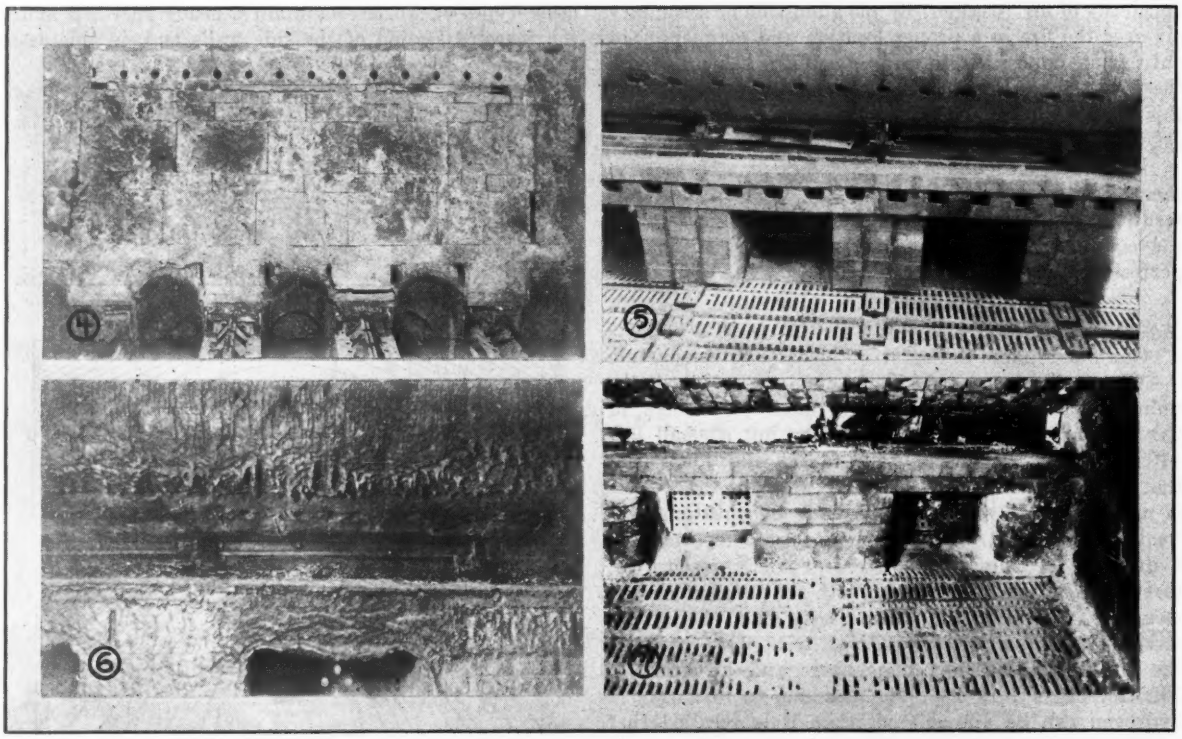
2. Admission of air, over the fire, in that section in which distillation of gases and ignition takes place, through nozzles designed to produce maximum turbulence.

3. Parallel principle of secondary air control, i. e.,

design of nozzles to admit predetermined volumes of air for a given static pressure in the plenum chamber, a coal of given volatile content, and a mean average expected rating; the pressure in the plenum chamber or drop through the nozzles to vary directly as the coal burned because the underfire and overfire air are arranged in parallel.

4. Admission of air, preheated by passing it through the walls, under that section of the fuel bed where the fuel is passing through the last stages of combustion, i. e., under the dumps or clinker grinder rolls.

Spaced brick or perforated blocks have been used to some extent, even in the smaller plants, but have often shown disappointing results. The outstanding reason for this poor performance is that air so introduced fails to penetrate into the furnace gas; that is to say, the air has been credited with prolonging the life of refractories by simply flowing along the surface of the walls. The accuracy of this assumption appears rather doubtful, as radiant heat shows a fine disregard for air blankets.



FIGS. 4-7. FURNACE CONDITIONS WITH AND WITHOUT AIR NOZZLES. FIG. 4. RILEY STOKER AFTER 5000 HR. AT 200 PER CENT OF RATING. FIG. 5. COKING SHELF WITH NATURAL DRAFT OVER FIRE ARCH OF HUBER STOKER. FIG. 6. OVER FIRE AIR WITHOUT AIR NOZZLES AFTER 2 MO. AT 200 PER CENT OF RATING. FIG. 7. DRIP LEDGE AND NOZZLE COMBINED IN ONE BLOCK.

Gas May Remain Stratified

Stratification of the gases, caused by the introduction of secondary air without turbulence, persists throughout the boiler. Figures 1 to 3 tell the story of stratification as it existed in a large furnace (400 sq. ft. grate surface) fired by an underfeed stoker, which may be accepted as one of modern type at that time. This was a result of the introduction of excess air through perforated air-cooled blocks to overcome lack of secondary air over the fire. These curves were plotted from the data gathered by analyzing gas samples taken simultaneously in the planes A, B and C, during several tests. For each given rating several tests were conducted, care being taken that rating and fuel bed condition were kept constant so far as possible.

Drip Ledge for Slag

To the writer's knowledge, the most successful installations of perforated clay blocks made are in the Hell Gate station of the United Electric Light & Power Co. of New York City. The success of these installations is largely due to the use of a drip ledge, which prevents, to some degree, the sealing off of the holes by flowing slag. To give the maximum service, this ledge should project from three to four inches and must be carried straight up for a distance of from four to six courses, before corbelling back is effected. This arrangement prevents loss of the ledge by mechanical stresses and greatly prolongs its life, thereby likewise prolonging the life of the perforated blocks underneath the ledge.

Air Introduced Through Nozzles

At high ratings, under conditions of flowing slag, spaced brick and perforated blocks are usually unsuccessful. The use of nozzles in conjunction with the use of secondary air, introduced for the purpose of cooling the furnace walls on its way to the furnace, represents the third step—perfection of the design.

Tests made by the author indicate that with underfeed stokers and certain types of overfeed, five per cent

of the total air can be used to advantage over the fire when the volatile averages from 18 to 20 per cent. As the volatile content increases, the secondary air requirement increases but at a more rapid rate. The heavier the fuel bed and the higher the rating, the more secondary air is needed for a given volatile.

It is fairly obvious that this amount of secondary air is sufficient to produce a degree of turbulence when admitted through nozzles under pressure.

Figure 4 illustrates the application of these principles by the writer. It shows the front wall, over a Riley underfeed stoker, after 5000 hr. of continuous service, at outputs up to 200 per cent of rating. The wall is absolutely intact and the blast through the nozzles has prevented any slagging over. Figure 5 is an installation of natural-draft, over-fire arch with Simpson coking shelf on a Huber stoker for a 400-hp. boiler. Figure 6 shows an over-fire air installation after two months of continuous service at a constant rating of 200 per cent.

The cost of the installation in Fig. 4 is approximately twice that of perforated clay blocks; its life at least four times as long. Even were the maintenance cost the same, this installation is justified on the basis of improved evaporation due to materially improved combustion conditions. Although incidental in this case, the reduction of smoke was noteworthy.

Figure 7 illustrates another successful installation, of which several have been made and in which a single block combines the drip-ledge with the nozzle.

Careful attention must be given to the details of the number, location and size of nozzles, but the preliminary engineering required is amply justified by the results obtained from correctly designed installations of this type. It has been found by experience that, to assure maximum effect from the secondary air, close attention must be paid to its velocity. The designing of secondary air jets, in relation to amount and velocity of gas flow, must be given careful consideration.

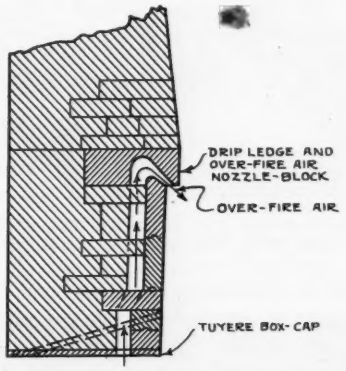


FIG. 8. CONSTRUCTION OF COMBINED DRIP LEDGE AND AIR NOZZLE FOR TAYLOR STOKER

Once the proper combination is established, for the average load, parallel operation insures the direct variation of over-fire air with the air forced through the fuel bed and proportions close to those theoretically required are automatically maintained.

Store Rooms for Power Plants

CONTINUOUS OPERATION OF PLANT PLACES DEMANDS ON STORE ROOM FOR ADEQUATE SUPPLIES IMMEDIATELY AVAILABLE

JUST HOW to care for, keep account of and issue the almost endless list of supplies, tools and spare parts that are essential to the continuous, efficient operation of a power plant is a problem of considerable moment. Supplies are needed in every plant, be it large or small, the only difference being the amount carried in stock. To be compelled to shut down a plant, or even an important unit, for an appreciable period of time because some common supply is not at hand and must be sent for is usually inexcusable on the part of the engineer in charge.

Nearly every power plant is provided with spare or standby units that can be rushed into service at a moment's notice. Usually failures of equipment are due to the breaking or wearing away of some rather detailed part, so that, if the engineer has studied his equipment and provided spares for the parts that are most likely to give way, he is in position to make permanent repairs in the shortest possible time.

What may be said about keeping on hand a sufficient quantity of supplies and spare parts may also be said in regard to tools. Many of the large power plants maintain their own machine shops and do practically all of their repair work. In the small plant, however, the heavy work is usually done outside but every chief engineer finds occasional urgent need for some tools of the portable type that should be made available to responsible men throughout the plant. These, when not in use, should be kept in the store room and given careful inspection when returned after use.

STORE ROOM EQUIPMENT

Too frequently an out-of-the-way corner of the power plant is the only space made available for the store room. Such a location is not conducive to order nor to convenience. The more nearly the store room can be located to the center of the plant, the better it will serve its purpose. In some plants entrance to the store room is through the chief engineer's office. This location has the advantage that the engineer or his immediate assistant may conveniently care for the store room and keep a line on how supplies are being used.

Another essential feature controlling the location of the store room is the convenience for handling the materials received. Excepting fuel, practically all deliveries to a plant in operation should pass through the store room. At least nothing of value to the plant should be permitted to enter or leave the premises without the knowledge and consent of the man in charge of the store room and without some written record of the transfer. Arrangements should, therefore, be made to have all materials received by the storekeeper preferably in the store room but if necessary at the place of use.

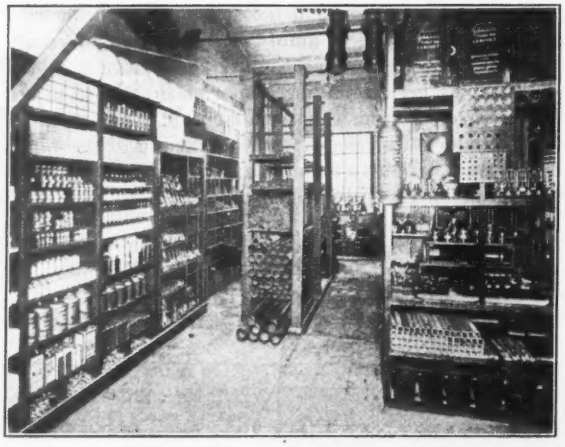


FIG. 1. CLEANLINESS AND ORDER CHARACTERIZE THIS STORE ROOM OF A GAS AND ELECTRIC COMPANY

Conveniences for storing materials must be provided. Open floor space is essential for heavy equipment, large castings, irregular shaped spare parts and large quantities of bulky supplies. Some plants store this type of material on lift truck platforms for convenience in handling. Strong shelves do well for all kinds of supplies that come in packages or cans that can be so placed that they will not fall off. For hand tools, small portable tools, small pipe fittings, nails and the like, partially boxed in and partitioned off shelves, commonly known as bins, are convenient as the contents can readily be seen yet will not roll off the shelves. Racks are used for storing strap iron, rods and piping. For small supplies like screws, rivets and washers, boxes that fit into pigeon holes in the shelving are preferred by many engineers. Close fitting drawers have their place in the store room for keeping supplies that must be kept clean, such as instrument charts and for delicate portable instruments, which could be locked up separately, or supplies that may be easily broken, scratched or otherwise damaged.

FIG. 3. BINS EQUIPPED WITH LADDER ON WHEELS ARE CONVENIENT FOR SMALL SUPPLIES

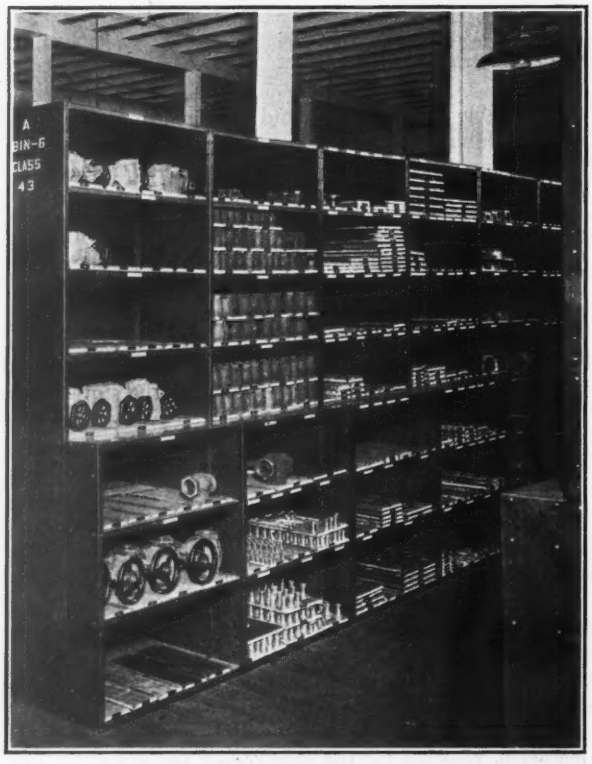


FIG. 2. STEEL SHELVING IS CONVENIENT FOR STORING VALVES AND PIPE FITTINGS

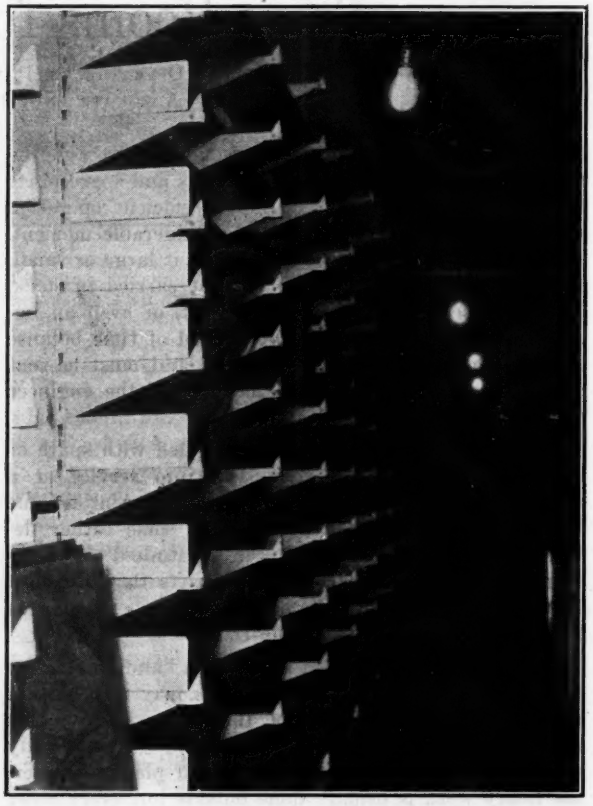


FIG. 4. RACKS OF THIS TYPE HAVE MANY ADVANTAGES FOR STORING PIPE

To aid the storekeeper in handling the supplies, ladders are indispensable; the type provided would necessarily conform to the individual needs of the plant. Trucks, also, are essential for transporting shipments of supplies, spare parts, portable tools and small equipment and in large store rooms of central stations hoists and cranes are in common use for loading and unloading heavy equipment from railroad cars and trucks which run directly into the storage space.

In modern plants, the general practice is to use shelving made of sheet steel, not alone because of its durability, which is a considerable advantage over wood, but because with standard shelving the spacing

FIG. 5. THE VARIETY OF BINS, SHELVES AND DRAWERS MAKES THIS TYPE OF CASE SUITABLE FOR SMALL STORE ROOMS

can be adjusted at will and the steel does not take up as much room as wood.

Responsibility for Store Room

Just who should look after the store room is a problem for each plant to solve. In large central stations the store room is a separate department of the plant with its own organization headed by a man reporting to the superintendent. Manufacturing plants usually have a similar arrangement which serves the entire factory of which the power plant is a part. In institutions and office buildings, it is quite common practice to keep all mechanical and electrical supplies in one store room under the control of the chief engineer. When storekeeping does not require the entire time of one man, a clerk can be employed to keep the plant records and look after the supplies in addition.

One essential condition must be maintained and that is, the store room service must be available at all times while the plant is in service. If the regular storekeeper is off duty the engineer in charge of the plant should be provided with keys that will admit him to the store room and he should be sufficiently familiar with the system employed to enable him to get supplies out of storage without getting the records mixed. In some industrial plants, the night watchman has keys and instructions that enable him to get materials and supplies when the regular storekeeper is off duty.

Under all circumstances order is essential in the store room. A complete index of every supply or spare part kept in the store room is positively necessary so that they may be instantly available. Common practice seems to favor designating each tier of shelves by letter, using whole numbers for the shelves and decimal numbers for the divisions of the shelves, each division being carefully labeled. Indexing of supplies is, of course, done alphabetically; spare parts, however, should be indexed under the machine for which they are intended by name and casting number, the latter being absolutely essential as slight changes in design usually affect the changeability of parts.

To be without needed supplies is to foster trouble in the plant as substitutes must then be used, frequently with disastrous results. Well-managed store rooms, therefore, keep a perpetual inventory of all supplies and when they reach certain minimum limits the supply is replenished. Just what the minimum should be is a question for each plant to decide. Certainly it should not run so low that there is any likelihood of exhaustion before the new supply arrives.

Spare parts to be kept in stock offer a distinct problem to the engineer. Familiarity with the equipment

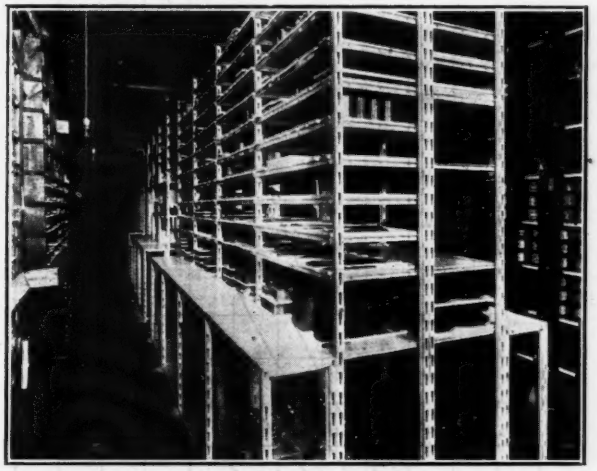


FIG. 6. STEEL SHELVING IS EASILY BUILT UP TO SUIT ANY REQUIREMENTS FROM STANDARD PARTS

under his care is the only guide as to what spare parts to keep in stock. Inspection time is the most favorable for determining weak or worn parts and deciding whether or not spares should be ordered for immediate or future repair work.

As usually operated, whether the store room is under the supervision of the engineer or a separate department of the institution, the supplies to be kept for the power plant are specified by the engineer in charge of the power plant. When supplies are needed, an order on the store room is given, signed by the engineer or his authorized assistant. These orders are in duplicate or triplicate, depending upon the system of record keeping; the engineer keeps one copy, the store room the second and in some cases the purchasing department is given the third copy.

Tools and portable instruments should also have a place in the store room and when issued for any particular job they are charged to the man who is to use them, holding him financially responsible for them.

Storekeeping in power plants should be made as simple as possible consistent with positive assurance that the needs of the plant will always be met and supplies, tools and instruments are not wasted, injured or stolen.

Heat Saving in Industrial Plants by Insulation

By L. B. McMillan, Consulting Engineer, Johns-Manville Corp., New York

ONE OF THE most profitable aids in heat conservation is heat insulation. Not only is the fuel equivalent of the heat saved an important item but often of equal or of even greater importance is the fact that the heat saved by insulation is the most valuable portion of the heat. It is the cream, so to speak; the high potential heat that costs most to produce and that does the most effective work.

High Temperature Heat Most Value

Power engineers do not need to be told that a given number of heat units at high potential will produce more power than the same number at lower potential; or that maintaining the required superheat will make all of the heat units more effective in the turbine than if dissipation of temperature head is permitted to degrade all of the heat; or that there is plenty of heat in the condensing water but useless because it lacks the required potential to make it capable of doing useful work. But the application of this principle to other industrial heat using processes is not so thoroughly understood.

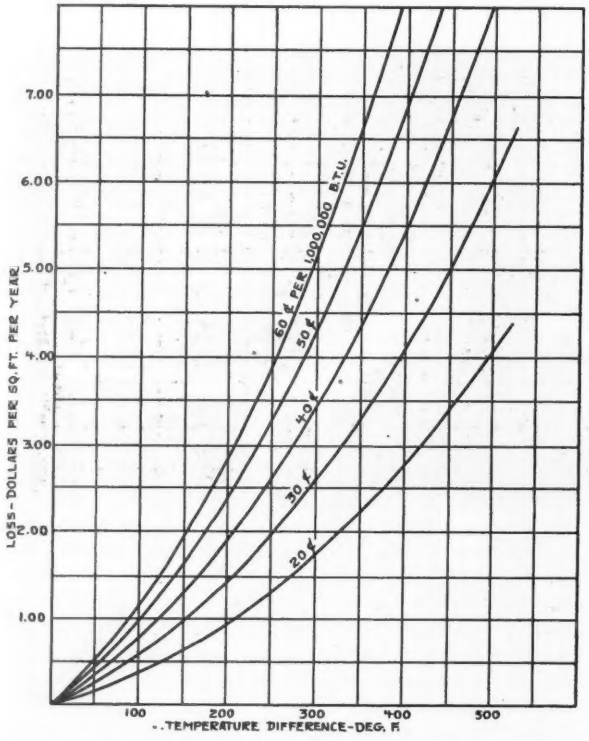


FIG. 1. ANNUAL HEAT LOSS COST AT DIFFERENT VALUES PER 1,000,000 B.T.U.

In the case of industrial furnaces, as for example a heat treating furnace, where very definite temperatures are required for the process, the generation and uniform maintenance of these temperatures are all important considerations. It costs more to effect the last 100 deg. of temperature rise than any preceding 100 deg. The heat lost through the furnace walls is from this most valuable portion of the heat; consequently the heat saved by insulation is much more valuable than its direct equivalent in fuel. For each heat unit effectively put to work in the product or process, perhaps many have been expended in the form of fuel. Nor is the saving of valuable heat and fuel the only benefit derived from insulation. Maintaining the required temperature at one point in the furnace is not enough. Insulation assists materially in maintaining uniformity of temperature throughout the effective zone of the furnace with the result that production is increased and quality of product is improved.

Nor yet do the advantages just outlined, important as they are, constitute the sum total of the benefits that accrue from decreased heat losses. Not the least of the advantages of heat insulation is its effect on the human element; the increased human comfort and improved working conditions in the vicinity of well insulated heat equipment. These factors are certain to bring about increased effectiveness of man power and increased productivity of labor.

Heat Lost Is Dollars Lost

In spite of the fact that it does not tell the whole story, a striking picture of the cost of heat losses from bare surfaces is shown in Fig. 1. In this chart the equivalent losses in dollars per square foot per year of 8760 hr., are shown for various values of heat per 1,000,000 B.t.u. This chart tells somewhat nearer the true story than would simply figuring the fuel equivalent of the heat loss, because the curve for value of heat may be chosen so as to represent the true value and not simply the fuel cost.

To bring out still more forcibly the magnitude of the dollar value of heat losses from bare surfaces, a specific example will serve. From the chart it is readily apparent that the loss from one square foot of bare surface at a temperature 300 deg. above room temperature and at a value of heat of 30c per 1,000,000 B.t.u. is $2.60 per year. Therefore, 100 sq. ft. of such surface (an area only 10 ft. square or 5 by 20 ft.) will lose $260 worth of heat a year. If the equipment is in use 7200 hr. a year instead of 8760, the loss is still $214 per year for 100 sq. ft. area. If the surface in question is on boiler drums, hot tanks or any other apparatus where the surface temperature is nearly the same as the temperature inside of the steel shell, insulation which will save upward of 90 per cent of this loss may be applied at a cost considerably less than one year's savings.

All of these figures on losses and savings are based on still air conditions. The effect of air circulation over a bare surface is to increase enormously the rate of heat loss. An air velocity of 10 mi. an hour will

at least double the rate of loss. On the other hand, the losses from insulated surfaces, where the resistance to heat flow is mostly inherent in the insulation itself, are increased but slightly in proportion by air circulation. Where the increase in heat loss from bare surface is of the order of 100 per cent, the increase in loss from a well insulated surface, with insulation tightly applied and thoroughly sealed so that air can circulate only over its surface, is of the order of less than 10 per cent. Therefore, where surfaces are exposed to air circulation, the savings by insulation are proportionately far greater than those referred to above.

Even if there are only a few square feet of surface at any one point such as on bare fittings, boiler drum heads and flanges, the total loss from a number of such areas may be startlingly large. This emphasizes the desirability of insulating such surfaces, which are frequently left bare even when adjacent piping is effectively insulated. A large number of small savings may be just as attractive as a few larger ones.

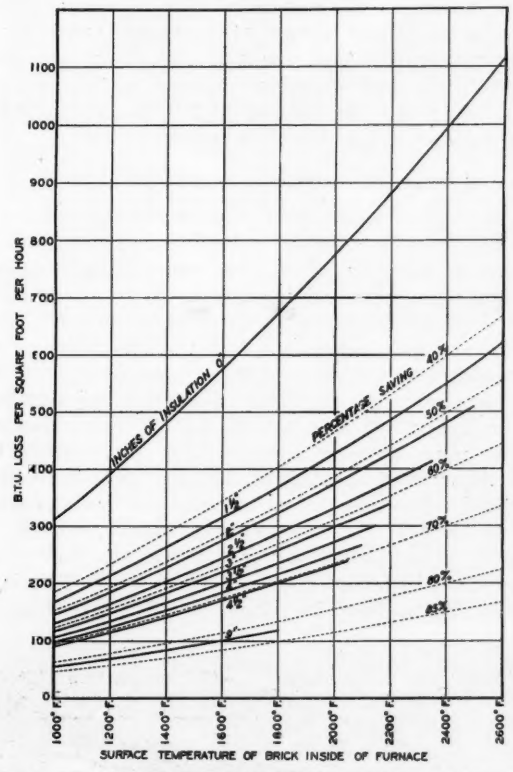


FIG. 2. HEAT LOSS THROUGH FIRE BRICK WALLS 13½ IN. THICK. SAVING BY USE OF SUPEREX BLOCKS OF DIFFERENT THICKNESS

Insulate Furnaces Too

Use of insulation on furnaces is also a most attractive source of heat savings in industrial plants. While the refractories offer some obstruction to heat flow, the interior temperatures are higher and the resultant heat losses may be even greater than for similar areas of bare steam-heated surfaces. The extent of losses from furnace walls and the savings effected by various thicknesses of insulation are illustrated graphically in Fig. 2. The usefulness of insulation in this field is just beginning to receive the recognition which it deserves. Materials are now available which withstand as satisfactorily the more severe conditions encountered in these higher temperature fields as other materials are well known to have withstood those in the lower ranges of temperature.

In conclusion, it may be said that the economics of heat insulation has become a rather exact science. Application of the principles evolved through research and experience cannot fail to serve industry not only in the way of heat savings but also in the way of increased production and increased productivity of labor, all of which tend toward decreased unit costs.

Fundamental Considerations Involved in Burning of Powdered Fuel

Studies of the problems connected with the burning of powdered fuels are being conducted by the United States Bureau of Mines at the Pittsburgh Experiment Station. One of the most important questions is that of the rate of burning of individual fuel particles. There are evidently two fundamental factors influencing this: first, the rate at which oxygen reaches the surface of the fuel; second, the fraction of the oxygen molecules reaching the surface, which react. The first factor will depend upon the amount of turbulence and the rate of diffusion of oxygen molecules, the latter increasing approximately with the square root of the temperature. The second factor, in accordance with known characteristics of similar reactions, will depend upon temperature in a larger degree. Obviously, then, at some high temperature the rate of burning of a fuel particle will be governed by the first factor, namely, the rate at which oxygen can reach the surface. The rate of burning may thus be governed by different factors at different temperatures, both as indicated by these considerations and also due to the fact that different combustion products may appear at different temperatures.

In commercial practice, of course, turbulence is depended upon to speed up the rate at which oxygen is supplied to the fuel. Another factor is the availability of the surface of the fuel particle. Parts of the surface may be more chemically reactive than others. Size of particle and physical structure are likewise of importance in this connection. Distillation and burning of volatile material from the fuel also has an effect on the process. The character of noncombustible material present is important, particularly with regard to its catalytic effect and possible enveloping of unburned material by the ash from the part previously burned.

Imperial Irrigation District, El Centro, Calif., is planning three hydroelectric projects at dams now owned by the district, with switching stations and transmission system for power supply for pumping operations and other service at different points in the territory. Permission has been secured from the State Bond Commission, Sacramento, to call a special election to vote bonds in amount of $1,700,000, the estimated cost of buildings, prime movers and auxiliaries. Authority has also been granted for a bond issue of $1,800,000 for extensions and improvements in the canal drainage system. M. J. Dowd is chief engineer.

Diesel Engines as Power for Industrial Plants

ECONOMY, DEPENDABILITY AND ADAPTABILITY TO ANY LOCATION ARE FACTORS IN INCREASING USE. BY EDGAR J. KATES*

TODAY THE Diesel engine is so simple and reliable as well as economical a prime mover, that progressive engineers take cognizance of it in practically every engineering study of power supply for industrial establishments.

At the start of the commercial application of the oil engine, its field was highly restricted by the natural conservatism, due to unfamiliarity with the engine and with its fuel. The first important use in this country was for driving the main pumps of oil pipe line systems.

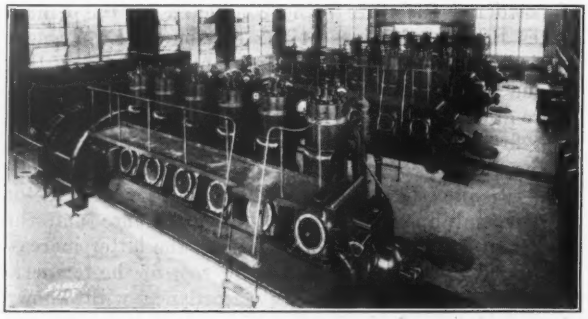


FIG. 1. FOUR 360-HP. FAIRBANKS-MORSE ENGINES AT LOUISIANA OIL REFINING CO.

Though the service was severe, the incentive to use Diesels was great, because of the great savings in fuel expense that would accrue during the long hours of continuous service at heavy load. Under such conditions, the annual fuel cost of a steam plant is large, and a Diesel installation that consumes only one quarter as much fuel will effect great economy.

Another reason why oil engines were early adopted by the pipe line companies was the greater familiarity of these concerns with the use of fuel oil for power purposes. Most of their steam-driven pumping stations had already been equipped with oil-fired boilers because of the convenience of using for fuel the same oil that was being pumped through the pipe line. It was, therefore, a natural step to use this oil as fuel for Diesel engines.

This early application of the Diesel engine to oil pipe line pumping was a useful rung in its ladder of progress. The very severity of the service put the new prime mover to the acid test. The pumping stations were in continuous service, 24 hr. a day, every day of the month and the load was large and steady, averaging 85 to 90 per cent of rating. Many improvements and refinements were the outcome and these have helped to fit the Diesel engine for other industrial uses.

TYPICAL APPLICATIONS OF DIESEL ENGINES

Oil engines have proved completely satisfactory to the pipe lines as regards reliability and economy. A typical month's record of three pumping stations, containing nine units and no spares, shows outage ratios of individual engines ranging from zero to a maximum of 1.3 per cent, the dependability of the entire system averaging 99.7 per cent. Another pipe line system that has been running 42 engines on continuous heavy load, 24 hr. a day, 365 days a year, for 15 yr., without any spare units, recently reported that the engines had been in duty 98 per cent of the total possible time!

Next in the important applications for stationary service was the electric central station. Here the Diesel's attractiveness lay in the fact that low power costs could be achieved even in small sizes. This is, of course, not the case with steam-driven central stations,

*Consulting Engineer, New York, N. Y.

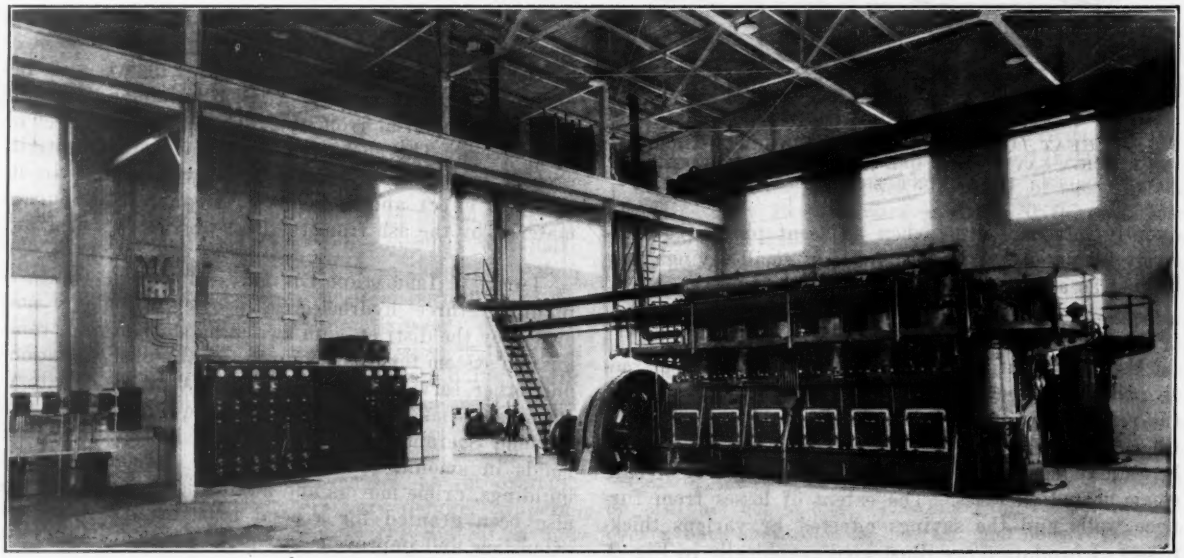


FIG. 2. TWO McINTOSH AND SEYMOUR DIESEL ENGINES DRIVING A.C. GENERATORS IN THE HICO PLANT OF TEXAS-LOUISIANA POWER CO.

where small plants are inherently inefficient and the highest economy is achieved only in large installations equipped with elaborate accessories. Between a Diesel of 100 hp. and one of 15,000 hp. there is less than 10 per cent difference in the fuel consumption per horsepower-hour. For several years, the small steam-operated central stations which first brought electric service to many municipalities in the central and southwest regions have been rapidly disappearing. Sometimes their places have been taken by current transmitted over long "high-lines"; in other cases the municipalities have installed oil engine central stations that have proved highly successful. Most of the Diesel central stations are of small size compared with modern steam super-power plants; but one of 7500-kw. capacity has been built and still larger Diesel stations are in prospect.

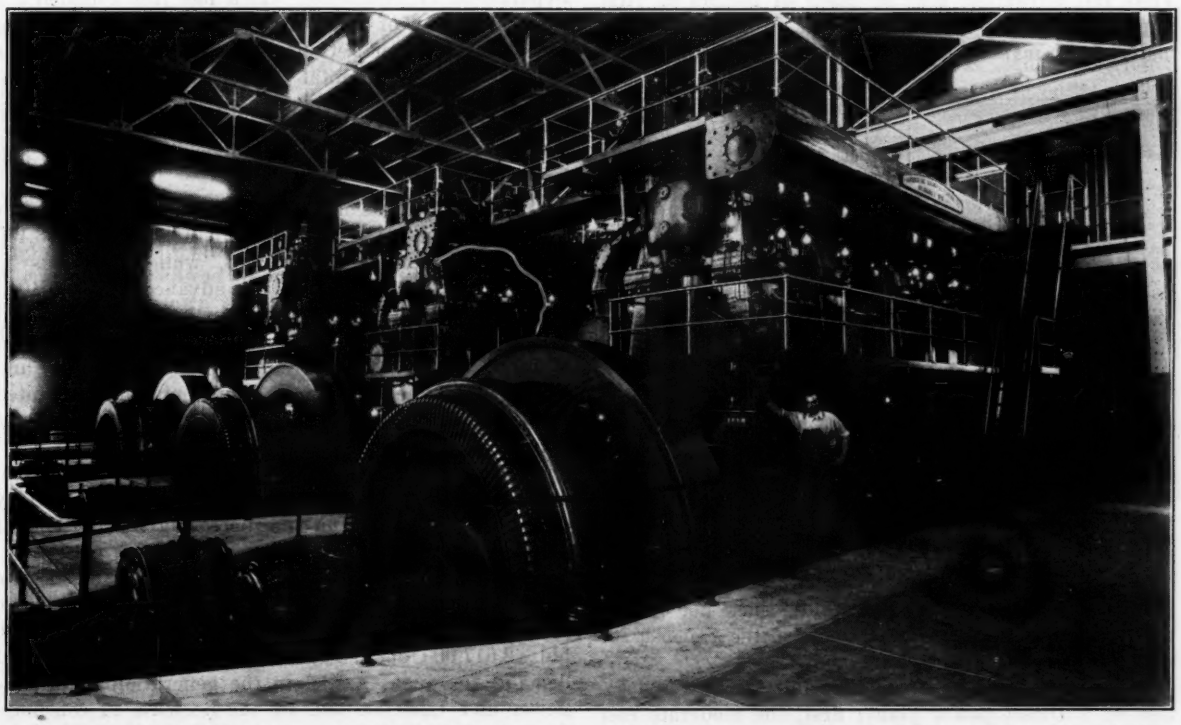


FIG. 3. PLANT OF COMMERCE MINING & ROYALTY CO., CARDIN, OKLA. THREE NORDBERG 2250-HP. ENGINES SUPPLY POWER FOR MINES, MILLS, ELECTRIC RAILWAY AND STANDBY SERVICE

Almost simultaneously with the application to central station service, a few large industrial power users became aware of the advantages offered by Diesel power and a number of important installations were made. Among these were the plants serving the mines of the Phelps Dodge Corporation, whose first Diesel engines, not being procurable in the United States, were imported from Europe. Later, American engines were added to make a total capacity of over 27,000 hp. in four plants.

Marine applications also became increasingly common. First, naturally, came those requiring only small engines, such as tug-boats, fishing boats and ferries. Later, as Diesels were developed in larger sizes, the large motorship appeared, until today more than half (56 per cent) of the tonnage of sea-going vessels under construction throughout the world is Diesel-powered. A few weeks ago the M. S. Augustus sailed on her maiden trip from New York to Italy, a passenger motorship powered with 33,000 br. hp. of Diesel engines and displacing 32,000 tons—more than the famous Mauretania.

In view of these impressive examples in other fields and particularly because of the Diesel's unique characteristic of delivering cheap power in small quantities, it seems strange that it was not more quickly seized upon by small industrial plants using from 100 to 1000 hp. The explanation is probably that the idea was novel, and a large number of individuals, both managers and engineers, had to be educated; also, considerable apathy to the cost of power existed because, in most industries, power was only a small item in the total cost of manufacture. No concerted effort was made to acquaint power users with Diesel information. In the meantime, extensions in electric transmission systems and intensive campaigns to sell electric power caused many industrialists to choose purchased current without paying much attention to the alternative cost of Diesel-produced power in plants of their own.

That period has passed. The urge towards volume production has created a buyers' market and brought competition of the keenest kind. Naturally, there has been a progressive lowering of selling prices, with corresponding reductions in profit margins. In many lines today, the profits come from hitherto overlooked savings in manufacturing costs and the cost of power is found to be a most fertile field for the cultivation of economy. Consequently, Diesel engines have been gradually and successfully introduced into almost every class of industry and they are now seldom disregarded when power problems are in mind.

Their success is not surprising. If a small central station can generate current with Diesel engines, trans-

mit it to a consumer, read meters, perform other services and still make a profit on the sale at a low price, it seems obvious that the consumer himself can use a Diesel engine of his own to make power still more cheaply. With his own plant the consumer profits by eliminating the transmission expense and losses, the commercial costs and the profits of the public utility company. Besides, he is freed from the annoyance and expense of transmission line outages and is also relieved from the surcharges, penalties and excess demand charges that are sometimes a source of discontent when power is purchased.

Oil engine power offers the industrialist other benefits, of a more general character. The most significant of these is freedom of factory location. An industrial establishment generating its own energy by Diesels may be located almost anywhere and still enjoy cheap power. Thus full advantage may be taken of factors of vital importance to the industry such as proximity to raw materials, to markets or to suitable labor. Using Diesel

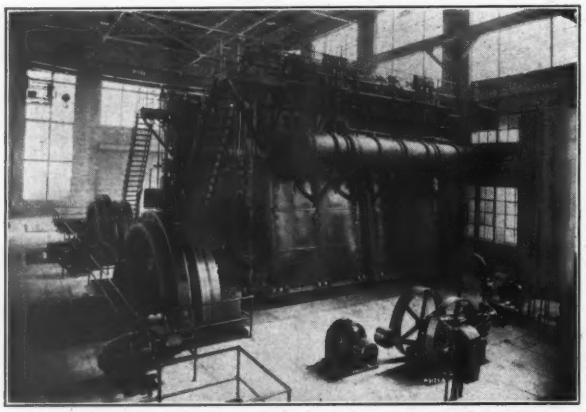


FIG. 4. TONOPAH, NEV., EXTENSION MINING CO. PLANT. TWO BETHLEHEM UNIT TYPE DIESELS DRIVING 1300-KW. A.C. GENERATORS AT 6000 FT. ABOVE SEA LEVEL

power in this way is doubly advantageous; not only is the power cost itself reduced, but also the expense for material-handling and factory labor.

Two factors are responsible for this freedom of location of a Diesel power plant: first, the moderate cost of transporting its fuel long distances (because so great an amount of power can be produced from a pound of oil); second, the Diesel engine requires only a small water supply. In both respects it far outranks a steam power plant. As regards purchased current, this often is out of consideration in remote localities, either because no transmission line has been built on account of the excessive cost, or because, if built, the power is too expensive. The freedom of factory location that is gained with a private Diesel power plant will in future commend it more and more to certain important industries.

Many aver that our social welfare demands the decentralization of our industrial system, i. e., more small factories located away from the big cities. The power needs of such factories can be economically supplied by Diesel engines.

Oil engine installations are now to be found in every section of the country and knowledge of their capabilities is therefore spreading more rapidly than ever before. This is, no doubt, the reason why so many Diesel plants are being built. Most of them are of moderate size and do not exhibit the spectacular features of present-day steam central stations. It will, therefore, surprise many to learn that the latest U. S Census shows that the value of oil engines manufactured in 1925 exceeded the combined value of all steam engines and all steam turbines combined, including even the huge turbines for the electric superpower systems.

Deliveries of Gas Oil and Fuel Oill Increase Dtring 1927

DELIVERIES OF GAS OIL and fuel oil, during 1927, including exports and shipments to non-contiguous territories, reached a total of 381,151,000 bbl., as compared with 372,381,000 bbl. in 1926, according to E. B. Swanson, economic analyst, United States Bureau of Mines, Department of Commerce, which has just completed a national survey of fuel oil distribution, in coöperation with the American Petroleum Institute. This increase of 8,770,000 bbl. in total deliveries resulted from increased shipments to foreign countries, as the quantities delivered within the United States showed a slight decrease from 334,030,000 bbl. in 1926 to 333,760,000 bbl. in 1927.

Shipments of gas oil and fuel oil to foreign countries increased from 34,516,390 bbl. in 1926 to 42,963,180 bbl. in 1927, or 24.5 per cent, while shipments to Alaska, Hawaii, and Porto Rico advanced from 4,104,505 bbl. in 1926 to 4,427,682 bbl. in 1927, an increase of 7.9 per cent. Increased shipments to North Central Europe, Mexico, Cuba, South America, China and Japan offset the decrease in shipments to the United Kingdom, Spain, France and Italy, accounting for the gain in exports.

Domestic demand for gas oil and fuel oil was stimulated by the increased requirements for bunker fuel by oil-burning steamers and the increasing installations of domestic and commercial oil-burning heating plants.

Deliveries of gas oil and fuel oil to gas and electric power plants decreased from 33,652,000 bbl. in 1926 to 29,775,000 bbl. in 1927. Of this decrease of 3,877,000 bbl., 2,617,000 bbl. is accounted for by the decreased demand for oil as a fuel in the generation of electric power and 1,260,000 bbl. by the decrease in consumption of oil in the manufacture of artificial gas.

Pacific Coast states continued to lead in the regional consumption of fuel oil, followed by the South Central and Middle Atlantic states. The North Central region, including mainly the states bordering the Great Lakes, showed the largest proportional increase in consumption, while the South Central and South Atlantic states showed decreases in requirements. A greater utilization of natural gas in Texas and Louisiana was mainly responsible for the decreased deliveries of fuel oil in the South Central states, while the decreased demand in the South Atlantic states was centered largely in Florida and was caused by a decrease in locomotive-fuel consumption by the single oil-burning railroad operating in that area and by the completion of certain dredging operations which had consumed relatively large quantities of fuel oil.

The complete report of the "National Survey of Fuel Oil Distribution, 1927," may be obtained by applying to the United States Bureau of Mines, Department of Commerce, Washington, D. C.

ELECTRICAL MACHINERY FOR LIGHT AND POWER

Transformer Loading-Back Tests

BECAUSE OF DIFFERENT TYPES OF LOAD CURRENT, CONDITIONS FOR TESTS MUST BE CAREFULLY SPECIFIED. BY A. NAETER*

WHEN ACCEPTANCE tests are made on large transformers after installation, heat runs form an important part. In order to reduce the losses while testing and also to make it possible to supply sufficient loading in case of large units, loading-back tests are in common use. It is customary to connect the low-tension windings of two similar transformers, or two halves of the same transformer winding, in parallel, while the high-tension sides are in opposition. The circulating current is introduced on the low-voltage side through a suitable step-down transformer which is usually supplied from the same source as the excitation of the

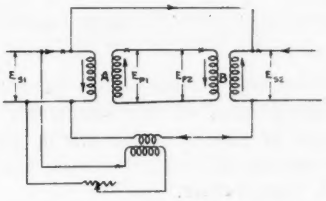


FIG. 1. SCHEME OF CONNECTIONS USED IN MAKING TRANSFORMER TESTS

transformer being tested. Several variations of the simple connections shown in Fig. 1 are in common use in commercial testing.

EQUIPMENT MUST CONFORM TO STANDARDS

Keen competition has resulted in a closer approach to the ultimate limits prescribed by the various codes, such as the A. I. E. E. Standardization Rules, N. E. M. A. Handbooks, etc. This condition requires careful testing in competitive tests in order that the best unit may be chosen from those submitted by the bidders. The writer recalls a test that he witnessed in which two small distribution transformers, say A and B, were compared. The tank of A was appreciably larger than that of B, while the weight and dimensions of the two units, excluding oil and tanks, were approximately the same. The two transformers appeared equally desirable on the bases of efficiency, distribution of losses and regulation; but B exceeded the prescribed temperature rise by a few degrees while A came just under the limit.

In large units, the phase relationships of the exciting and the circulating currents require careful consideration. When a transformer is loaded externally, the phase angle between the secondary terminal voltage

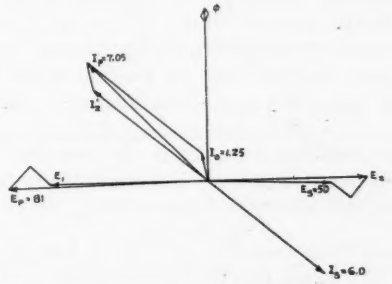


FIG. 2. PHASE RELATIONS IN TRANSFORMER FOR AN 80 PER CENT POWER FACTOR LAGGING

and current is determined entirely by the characteristics of the load, e. g., the phase relations for an 80 per cent power lagging factor load may be shown as in Fig. 2 for a certain transformer. Now when this same transformer is loaded with a non-inductive load current of the same value, the phase relations have changed to

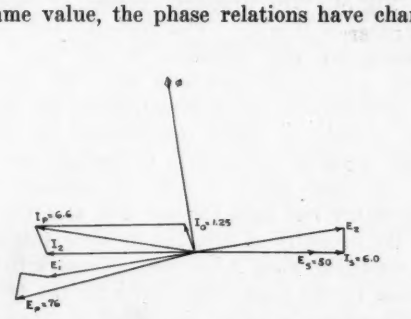


FIG. 3. PHASE RELATIONS IN SAME TRANSFORMER AS THAT FOR WHICH PHASE RELATIONS ARE SHOWN IN FIG. 2 BUT WITH A NON-INDUCTIVE LOAD CURRENT

that shown in Fig. 3. A comparison of these two figures will show that the total primary current in Fig. 3 is appreciably smaller than that in Fig. 2. Now, if the transformer were tested for temperature rise under these two conditions of loading, it would run cooler in the second case. At times, this difference in temperature rise is sufficiently large to affect the terms of the purchase specifications.

*Assoc. Prof. Electrical Engineering, Michigan State College.

On one occasion a group of transformers was rejected because the temperature rise on a full-load heat run, by the opposition method exceeded the guarantee. It so happened that the manufacturer had tested this particular group with a non-inductive load, and had found the temperature rise to be satisfactory. Consequently, a careful investigation was undertaken to determine the source of this discrepancy in test results. It was found that the phase relations of the exciting and the circulating currents approximated more nearly those of Fig. 2 instead of Fig. 3 as in the acceptance test, hence the excessive temperature rise. In an opposition test, the angles between the applied voltage and the exciting and the circulating currents are determined entirely by the relative values of the open-circuit and the short-circuit resistances and reactances. The manufacturer had used the test by loading while the purchaser had taken the opposition method in the acceptance test.

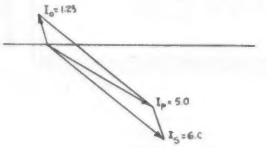


FIG. 4. CONDITION FOR TRANSFORMER B IN FIG. 1

Before considering in detail the question of phase relations in pump-back tests, it is desirable to call attention to another factor.

When Two Transformers of Fig. 1 Are Not Under Same Heating Conditions

Referring to Fig. 1, at a certain instant the light arrows indicate the directions of the magnetizing currents while the heavy ones show the circulating currents. Let it be assumed that the phase relationships are those shown in Fig. 2. Inspection of the wiring diagram shows that the conditions for transformer A are those shown in Fig. 2 while those of transformer B are indicated in Fig. 4. The primary current of transformer A is 7.05; that of B is 5.0. This indicates that these two transformers are not subjected to the same heating conditions. (A transformer with relatively heavy magnetizing current was chosen intentionally for the vector diagrams in order to better demonstrate the points of theory and practice that are to be brought out in this article.) In some cases, it may be necessary to take the temperature rise data for one unit at a time. This suggests the necessity of arriving at some suitable compromise condition when it becomes necessary to test one transformer by the pump-back test with the two halves of the high-voltage winding connected in opposition.

This situation brings it about that in good commercial testing only one transformer can be tested at a time for temperature rise by the loading-back method provided that a second unit of similar size and characteristics is available and that the phase relations within the one transformer are correct.

The question of immediate importance is the test method to be followed in order to get the proper phase relations. A study of Fig. 5 will show that the excitation is supplied by phase X and the magnitudes of the primary currents when a circulating current of the same magnitude is supplied in turn by X, Y and Z phases. The current I_x corresponds to the condition of 80 per cent power factor loading as shown in Fig. 2, while I_y corresponds to a current of leading power factor in this particular transformer. The effect of interchanging the terminals which supply the circulating current is made clear through a study of Figs. 2 and 4. This indicates the possibilities of phase shifting when three phase voltages are available without resorting to special phase-shifting devices.

In the 1925 Standards of the A. I. E. E., section 13-215 (b), is made this statement with regard to loading-back tests with duplicate single-phase transformers: "One transformer may be held under normal voltage and current conditions while the other may be operating under slightly abnormal conditions."

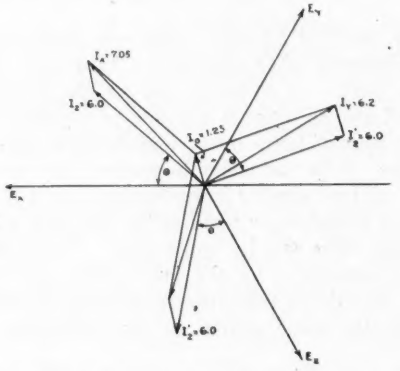


FIG. 5. VECTOR DIAGRAM TO SHOW PHASE RELATIONS IN TRANSFORMER

The considerations of this article have attempted to explain the significance of this statement. Failure to take cognizance of this situation might, under certain conditions, mean the difference between acceptance and rejection of a transformer.

World consumption of incandescent lamps is estimated at more than 600,000,000 per yr., of which Great Britain uses 41,000,000. Dutch production is said to surpass that of Great Britain. The collective annual output of European lamp factories including Great Britain is estimated at about 200,000,000.

The United States consumed 305,000,000 large tungsten lamps in 1927. The miniature lamps used, including flash-lights, automobile lights, Christmas tree lights and miscellaneous, were 205,000,000. Carbon miniature lights, most of them Christmas type, were sold to the amount of 14,500,000.

It has been estimated that the average home requires about seven lamp renewals in a year. This would account for the consumption of approximately 123,000,000 lamps a year. For each million new homes added, at least 22,000,000 lamps are installed, which, if sockets are assumed in halls, closets, basement and exterior, may reach 27,000,000.

The E. E. Hilliard Co., Inc., has approved plans for a hydroelectric power plant at its local woolen mill at Buckland, Conn., and will proceed with work at once. Charles T. Main, Inc., 201 Devonshire St., Boston, Mass., is consulting engineer.

Electricity---What It Is and How It Acts*

PART XIV. INTERACTION OF MAGNETIC FIELDS UPON ELECTRIC CONDUCTORS. NATURE OF INDUCTANCE AND ITS EFFECT UPON CURRENT

WHEN TWO CONDUCTORS, carrying current in the same direction are placed parallel to each other they will be drawn together because of the interlinkage of their magnetic fields. This action was discussed in detail in the previous article.

With a knowledge of such attraction (or repulsion in case of currents flowing in opposite directions) the question arises as to what effect such deflections have upon the currents in the conductors. We know from simple mechanics that to every physical action there is an opposite and equal reaction. What, if any, is the reaction in this instance?

To explain this, it will be necessary to consider again the production of a magnetic field by a current. An electric current, it will be recalled, is simply the parallel motion of a large number of electrons. Since each electron as it moves produces a magnetic field, it is obvious that the intensity of the magnetic field due to a current is equal to the sum of the field intensities of the individual charges or electrons.

In Fig. 1 are shown two parallel wires, each carrying a certain current I. Each current creates a magnetic field of a certain intensity ϕ. If the wires are placed close to each other, as in the diagram, the total field surrounding the two wires will be 2ϕ. Thus, the effect of placing the two wires close together is the same as though the current in one wire had been doubled, that is, increased to 2 I. Since this relation holds true for all values, it may be written in the form of an equation

$$\frac{\phi}{I} = L$$

in which ϕ is the intensity of magnetic field surrounding the circuit, I is the current in the circuit, and L is a constant of the circuit, commonly known as the *inductance* of the circuit.

NATURE OF INDUCTANCE

Inductance, unlike resistance, is not a function of the material of which the conductor is made but is a function of the shape of the circuit. This will be evident when it is recalled that the intensity of magnetic field due to a certain current in a conductor is dependent upon the shape of the conductor. Since inductance is a property dependent upon the magnetic field, it follows that inductance is a function of the shape of the circuit; the inductance of a certain length of conductor made into the form of a coil or solenoid being greater than that of the same length of conductor stretched out as a straight wire.

When a current is sent through a conductor, we have seen that when the current is first started a certain amount of force must be applied in order to build up a magnetic field. Once the current reaches a steady value, however, and the magnetic field is fully created, no more force need be applied. In actual practice, however, where the current passes through ordinary metallic conductors, a certain force must be applied to overcome the resistance of the circuit. This resistance is due to the fact that the moving electrons continually collide with the atoms of the material making up the conductor. This energy spent in overcoming the resistance is transformed into heat and will not be restored when the current is stopped. In this respect, it is unlike the energy spent in building up the field.

Suppose now we consider the circuit shown in Fig. 2, consisting of a coil in series with a battery and including a switch through which the circuit is completed. When the switch is closed, an electromotive force is suddenly applied to the electrons in the wire. This electromotive force will be spent in two ways as already explained, first in causing the electrons to move against the resistance offered by the molecules and atoms of the conductors, and second in effecting the distortion of

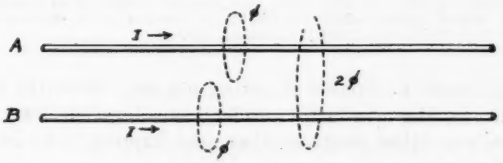


FIG. 1. TOTAL FLUX SURROUNDING TWO WIRES, IS SUM OF FLUX SURROUNDING INDIVIDUAL WIRES

the electrostatic field and setting up the magnetic field. The force required in the latter action is the same that would be required to set the electrons in motion in vacuum.

ENERGY STORED UP IN THE FIELD

When the force (electromotive force) is first applied, all of it (ignoring here, that used in overcoming resistance) is available for accelerating the electrons. As the electrons start to move, however, the electric field is distorted and a reactive force (counterelectromotive force) appears as already explained. When the speed of the electron is such that the counterelectromotive force exactly balances the electromotive force, the speed remains constant and no more energy need be applied. The amount of energy that must thus be expended in establishing the steady value of current and in the creation of the corresponding amount of magnetic flux, will depend directly upon the inductance of the circuit. The greater the inductance the greater is the work required to start the current and the greater will be the energy restored to the circuit by the collapsing magnetic field when the electromotive force is removed. A large electric generator may have a great deal of energy stored up in the magnetic field of its field coils. For this reason, it is never wise suddenly to open the field switch of a generator, since the sudden collapse of the magnetic field may build up a high voltage which will flash across the contacts of the switch in the form of a powerful arc. Field switches are usually provided with

*All rights reserved.

resistances which absorb this energy when the circuit is opened.

Referring again to Fig. 1, it must be evident that during the time that the current was building up, there was an unbalance between the electromotive force and the counterelectromotive force and therefore also a difference between the driving and reacting electrostatic fields. This produces a resultant electrostatic

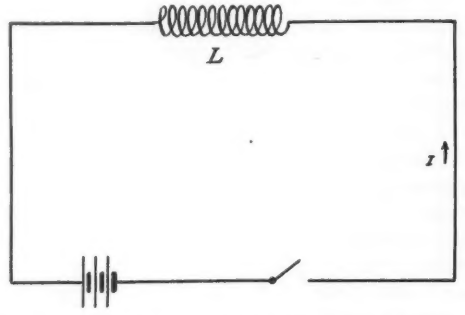


FIG. 2. SIMPLE CIRCUIT CONTAINING A SOURCE OF E.M.F. A SOLENOID AND A SWITCH

When the switch is closed the e.m.f. impressed across the circuit is spent in two ways, first, in overcoming the ohmic resistance of the conductor, and second in establishing a magnetic field through the coil L. The component used in overcoming the resistance is continually radiated as heat but that which establishes the field is needed only during the time the field is actually building up.

field, which is capable of acting not only upon the electrons in the conductor under consideration but also upon any other electrons that may happen to be in the field.

Electromagnetic Induction

Thus, if we place another conductor or coil in close relationship to the one shown in Fig. 2, as in Fig. 3,

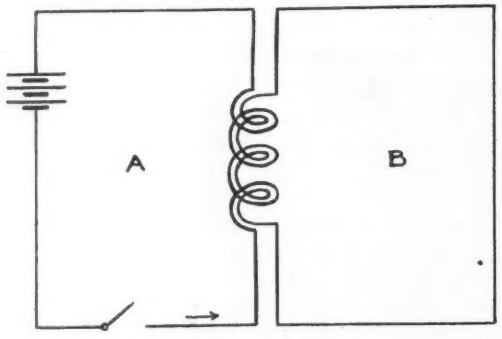


FIG. 3. CIRCUITS SHOWING THE PRINCIPLE OF ELECTROMAGNETIC INDUCTION

this resultant field will tend to accelerate any free electrons in this circuit. If this coil is closed upon itself as indicated, the electrons so set in motion will constitute an electric current. Thus it is possible, by means of a current flowing in one circuit, to induce another current in an entirely separate circuit having no electrical connection whatever with the first. This is known as electromagnetic induction and was discovered by Michael Faraday in 1831. It is the basic principle of all electric generators and motor equipment.

In this explanation, the curious reader may wonder just why the magnetic field should set the electrons in an outside conductor in motion. What is the mechanism involved?

To explain this, we must keep in mind the method of producing the magnetic field. In Fig. 4, at the left, is shown a circuit containing a source of electromotive force which in producing a current I establishes a magnetic field around the conductor A as shown. Suppose, now that the current is suddenly increased by increasing the electromotive force. It is evident that after the increase in current has occurred, the lines of force constituting the magnetic field will have increased in radii.

In an adjacent circuit which does not contain a source of electromotive force, consider a point p on the conductor B. When the current in A is steady, the direction of the magnetic field due to this current at the point p will be in a direction X, that is, tangent to the circle of flux passing through that point. During the time that current in A was being increased from a value I, to a value I_2, the circle of magnetic flux was increased in radius and the magnetic force X was dis-

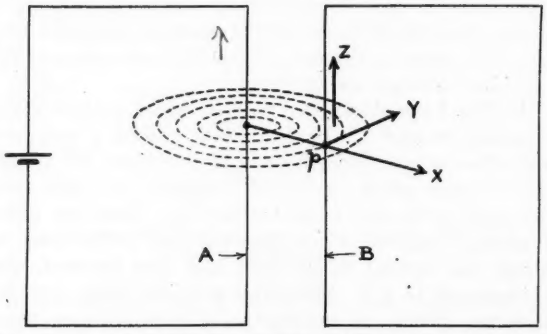


FIG. 4. TWO CIRCUITS, SHOWING HOW AN EXPANDING OR CONTRACTING FIELD IS CAPABLE OF INDUCING A CURRENT

placed without changing its direction. This displacement was along the line X.

Now, it is an interesting fact that many processes in nature are reversible and this is particularly true in electricity. We have shown how a moving electric charge will produce a magnetic field the direction of which is at right angles to the motion of the charge. In the same manner a moving magnetic field will produce an electrostatic field at right angles to the direction of motion of the field.

Thus in Fig. 4, the direction of motion of the magnetic field is in the direction X and with the direction of flux toward Y, an electric field, Z, will be produced. This electrostatic field, being parallel to the direction of the electrostatic field causing the increase in current I, is perpendicular to X and Y. If, under these conditions, an electric charge is placed at p, it will be set in motion along the line, Z, and in a direction depending upon the polarity of the charge. It will be recalled that a positive charge moves in a direction opposite to that of a negative charge when placed in an electric field.

It must also be remembered that these effects take place only when the magnetic field is actually expanding or contracting, that is, when the current in A is actually being increased or decreased. If the current

is being decreased instead of increased as supposed, the reverse effect will take place. The tendency of the induced electromotive force, as this force Z is called, is always in a direction such as to oppose the force producing it.

Reaction of Motion of Conductor Upon Currents

This then provides us with a clue as to what happens in the conductors when two current carrying conductors are attracted or repelled, due to their magnetic fields. It must be evident that the phenomenon described above will take place regardless of whether the secondary circuit (the right hand one in Fig. 4) carries a current or not. If it is already carrying current, the induced current will tend to diminish its flow.

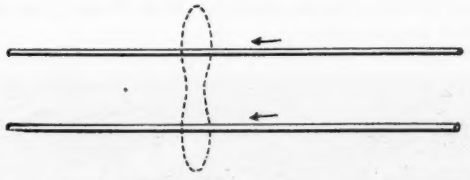


FIG. 5. WHEN TWO CONDUCTORS ARE MUTUALLY ATTRACTED DUE TO THEIR MAGNETIC FIELDS, THE CURRENTS IN THEM ARE MOMENTARILY DECREASED

In Fig. 5 are shown the same two conductors shown in Fig. 4 of the previous article.[1] Because their currents flow in the same direction, their magnetic fields tend to pull them together. As the conductors approach each other, the magnetic field of one will cut adjacent conductor, thus inducing therein a current which opposes the current already flowing. Each conductor acts upon the other in the same manner, so the result of the attraction is a momentary diminution in the currents in both.

It must be understood here that, in so far as the induced current is concerned, it makes no difference whether the motion of the field across the conductor is obtained by increasing the current, thereby causing the circles of force to expand, or whether one or the other conductor is moved bodily relative to the other. In each case, the field cuts the conductor, so to speak, and a current is induced.

If the conductors of Fig. 5 carry currents in opposite directions as in Fig. 6, the result is the same. In this instance, the conductors are repelled and the fields cut the conductor in a direction opposite to that which occurred when the conductors were attracted. This results in the induced current having an opposite direction relative to that in Fig. 5 but since the normal current is also in the opposite direction, the result is the same, i. e., the normal current is momentarily diminished. Since the impressed electromotive force remains constant, it is evident that more work is done during the momentary diminution in current. The work is that required to cause the deflection of the conductors.

We have now explained the three fundamental properties of the electric circuit, resistance, capacitance and inductance. No attempt has been made to discuss the various applications of these properties in electric circuits, nor have we attempted to enumerate the laws which govern their effect upon the electric current. In this series of articles, we are concerned primarily with the reason for the existence of these properties. We are less concerned, here, with a knowledge of the right-hand rule, which serves to express the directional relationship of magnetic flux, direction of motion and resultant force, than we are in knowing why an expanding or contracting electromagnetic field will set an electric charge in motion.

The hero of this story is the electron. His (or her, if you prefer) virtues are so numerous, that we shall require all the space at our disposal to recount them. The electron is at the root of everything in electrical science and it is the purpose of this series of articles to show how the electron is related to all the complex phenomena with which we are familiar today.

From a mere abstraction, the electron has grown to be the most important physical entity in the universe. Thus far, in these articles, we have been able satisfactorily to account for all electrical and physical phenomena in terms of its action. As we proceed, the idea of the electron as being the ultimate building block of the universe will become increasingly clear.

Before we proceed, however, it may be of interest to know something more about the manner in which the electron was discovered. This was promised in the first article of this series but was delayed purposely for the sake of providing the reader with a better knowledge of the apparatus used in its discovery. One of the elements involved in the discovery of the electron, for instance, is the displacement of an electric charge in an electric field and it would have been difficult to explain this to readers who had no previous knowledge of the principles involved in such displacement.

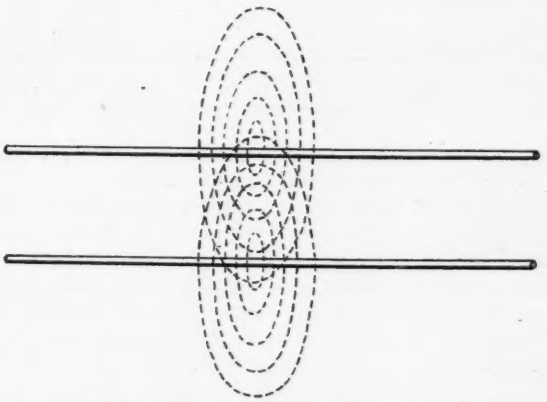


FIG. 6. REPULSION OF CONDUCTORS DUE TO MAGNETIC FIELDS ALSO CAUSES DIMINUTION OF CURRENT IN THE CONDUCTORS

This has now been explained[2] as have other phenomena, so that, in the forthcoming article dealing with the discovery of the electron, the reader need take little for granted.

[1]Part XIII, November 15 issue.

[2]Part VI, August 1 issue, p. 825.

Southern California Edison Co., Los Angeles, Calif., has approved plans for the complete rebuilding of Kaweah hydroelectric plants No. 1 and 2 to provide automatic operation of both units. The No. 1 station, built in 1899, has a capacity of 1900 hp. in three units. The No. 2 plant, built in 1924, has the same capacity. Rebuilding work is estimated to cost about $160,000.

Light in Industrial Plants Should Be Ample

No Glare, Even Distribution of General Lighting and High Intensity at Working Points Are Essential. By R. J. Malcomson*

PRECISION of work which is done under the guidance of vision cannot be greater than the accuracy of seeing. Speed, accuracy and economy of production are largely dependent on illumination, whether it be

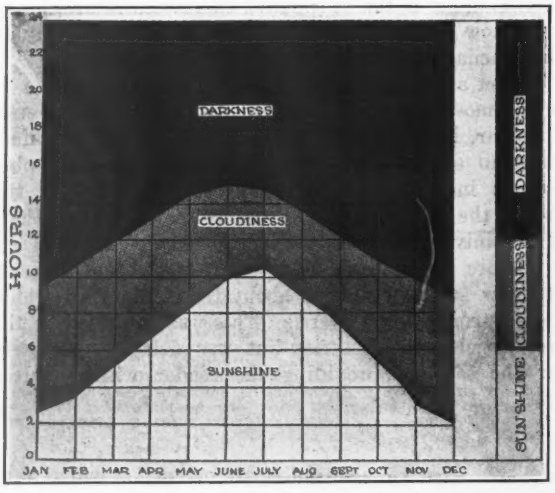


FIG. 1. YEARLY VARIATION IN SUN, CLOUDY AND DARK WEATHER AT CLEVELAND, O.

natural or artificial. Some work can be done with little light but more can be done with more light.

Production and work are nothing more than a man and a machine. Modern machinery is wonderful—almost human—but somewhere, even with the most intricate machine, there must be a man to guide it or possibly merely to watch over it. There must be an office to develop the plans for the machine to carry out and men must work in this office.

Good Illumination Aids Production

If we can save some of man's time, we save the machine's time and, as a result, increase production. Production and good illumination go hand in hand. Good lighting and decreased production costs go hand in hand.

Many plants are fortunate in having a great deal of window space and schedules in the factory are such that most of the work is done during daylight hours. Yet natural daylight cannot do the entire job; every plant should also have artificial illumination when the days are overcast. Figure 1 shows the hours of sunshine, cloudiness and darkness during the 24-hr. period at Cleveland, Ohio, over a period of 29 yr.

Many people, unfortunately, regard light as a commodity in the production of a thing. They believe that a lighting installation can be made to yield 10, 20 or 30-foot-candles on the working plane, and they consider this general treatment of the lighting as sufficient for the particular operation in question.

To register an image, the human eye requires a certain amount of time. The speed of registering in the eye is dependent upon the amount of illumination; as the illumination increases, the eye registers more rapidly. A glaring light causes the eye to contract and a dim light expands the pupil of the eye.

Glare Results in Slow Seeing

An eye subjected to glare cannot shut out the light swiftly enough and the result is a blinding effect. This is experienced even in daylight when looking at bright windows or sunlight.

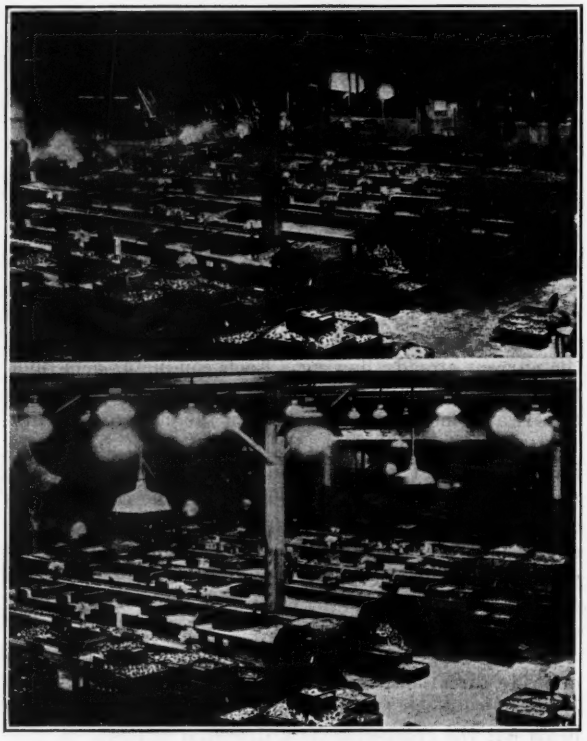


FIG. 2. BEFORE AND AFTER RELIGHTING THE INSPECTION DEPARTMENT, TIMKEN ROLLER BEARING CO. OLD, 2 TO 5 FT.-CANDLES, UNEVEN. NEW, 20 FT.-CANDLES, EVEN

Illumination is needed for the eye to see and discern objects. In ordinary work, the eyes shift about and see objects, first in one place and then in another. The illumination at the two places may be far different and the eye must necessarily adjust itself to new conditions. If the eye must shift from dark to bright areas, the ability to see quickly and clearly is hampered. The high intensity of the bright area aids seeing but the low intensity of the dark area acts as a handicap. Good lighting should eliminate all great differences in illumination between various areas.

Much tradition has been bound into the artificial lighting practice of the past centuries. The first step in the development of lighting came when lighting was rec-

*Manager, Lighting Sales, Public Service Co. of Northern Illinois.

ognized as a science. The old theory that "the lighting is good enough" was doomed. The stringing up of any old lamps is no longer considered sufficient and good lighting today is a proved economy.

General illumination for the entire working surfaces became the recommendation of the lighting engineer. This was a logical step from the old localized lighting of the past. The work done in elevating the intensity of illumination throughout the factory did much to speed up production.

Localized Lighting Should Be Added

We cannot have good lighting without general lighting of good quality, hence general lighting throughout the factory has been the demand of the lighting specialist. While this is of vital importance, localized lighting for individual operation is also of great importance. In many cases, the lighting system is planned and installed with respect to the size of the room. Machines used in that room are usually fixed in their positions so that, if adequate illumination is to be provided for individual operations, some provision must be made for additional localized lighting.

Lighting standards which we accept today are not only on a better level than those of a few years ago, but the future points to much higher intensities. The need of a definite lighting program for the future is a vital factor with every industrial executive. We have seen the local lighting of individual machines replaced with general lighting for the entire factory or working floor.

In this planning to get better illumination of higher intensities, care must be exercised to supply local light to operations requiring a high degree of skill or precision. General lighting will best meet the requirements of the job when it is supplemented with well-designed and properly located local lighting.

The worker must be able to see and discern objects about him quickly; material must be easily, quickly and safely moved under adequate lighting conditions but the worker must have supplementary localized lighting when the nature of his work requires it. Localized lighting is coming into use more and more each day as a supplement to good, general lighting. As the name implies, general lighting should be used for general purposes and localized lighting for seeing special operations.

Lighting Should Be Planned for Each Case

This brings us to the question,—how much light is enough? If all manufacturing operations in all factories were the same, it would be a simple matter to recommend and install one general type of lighting. This, however, is not the case. Instead there is a wide divergence in lighting requirements and each case should receive individual attention.

In recent years, lighting standards have risen and they will continue to rise as less expensive lighting equipment and more economical sources of light are developed.

At the Timken Roller Bearing Co., a recent test definitely proved the direct relation which lighting bears to production. It was found that under a higher level of illumination 43 more bearings could be inspected each hour, or an increase of 12.5 per cent and the cost was only 2.4 per cent of the payroll for this better lighting. Based on two per cent of the pay roll, the weekly lighting cost would be only $2 for a $100-pay roll, $10 for a $500-pay roll and so on.

Standard tables of minimum and recommended illumination for nearly all factory operations have been worked out by recognized lighting authorities, and are considered conservative statements of good lighting practice. Copies of these standards may be had from the lighting division of any central station company.

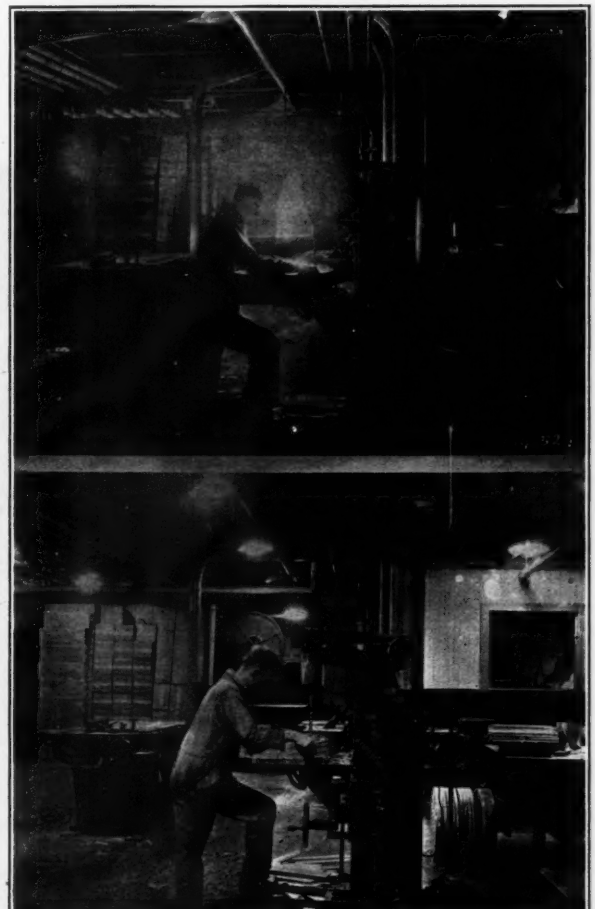


FIG. 3. GOOD GENERAL LIGHTING TO AVOID GLARE WITH INTENSITY OF LIGHT ON THE WORKING SURFACE ARE ESSENTIAL

Expert lighting advice and diagnosis are always available without charge. Manufacturers of lighting equipment are always improving their equipment, and progressive public utilities are qualified to recommend the proper practices.

Good lighting is economical. Good lighting of a high illumination intensity has an immediate effect in increasing production, decreasing spoilage, promoting better vision and relieving eye strain and fatigue.

Good lighting has been a substantial contributor to decreasing accidents for inadequate lighting is a major cause of industrial accidents. Good lighting also maintains morale and cuts down labor turnover.

To have good lighting is more a matter of definitely determining to make it always a part of your program rather than to make it a matter of cost.

Motor Drive Controls Paper Machine Accurately

Close Regulation Over Wide Speed Range Secured with Push-Button Control and Automatic Regulators. By F. W. Buck*

SUCCESSFUL DEVELOPMENT of sectional drive for paper machines has been an important factor in the recent advance in the art of paper making, the marked increase in the size and speed of paper machines being largely due to greater accuracy of control possible through improved driving methods. A modern high-speed paper machine is several hundred feet in length. From stock that is fed to it in diluted form it produces a sheet of paper that is practically free from moisture.

Due to the changes that take place in the sheet as it forms and dries, the machine must be operated as a battery of independently driven units, each one of which must operate at just the speed that will compensate for the elongation or shrinkage of the sheet. Since the paper is the only mechanical connection between the various sections of the machine, the relative speed of the sections must be maintained with the utmost accuracy, otherwise the sheet will gather slack or break.

Until recent years, steam engines or turbines were in almost universal use, the power being transmitted to the various sections through a long backline shaft, equipped with countershafts, gears, cone pulleys, belts and other mechanical devices. This equipment is complicated, difficult to regulate and relatively expensive to maintain.

Electrical engineers have devoted a large amount of research and experiment to the solution of this difficult problem seeking to develop a type of drive that shall be simple and flexible in operation and inexpensive to maintain.

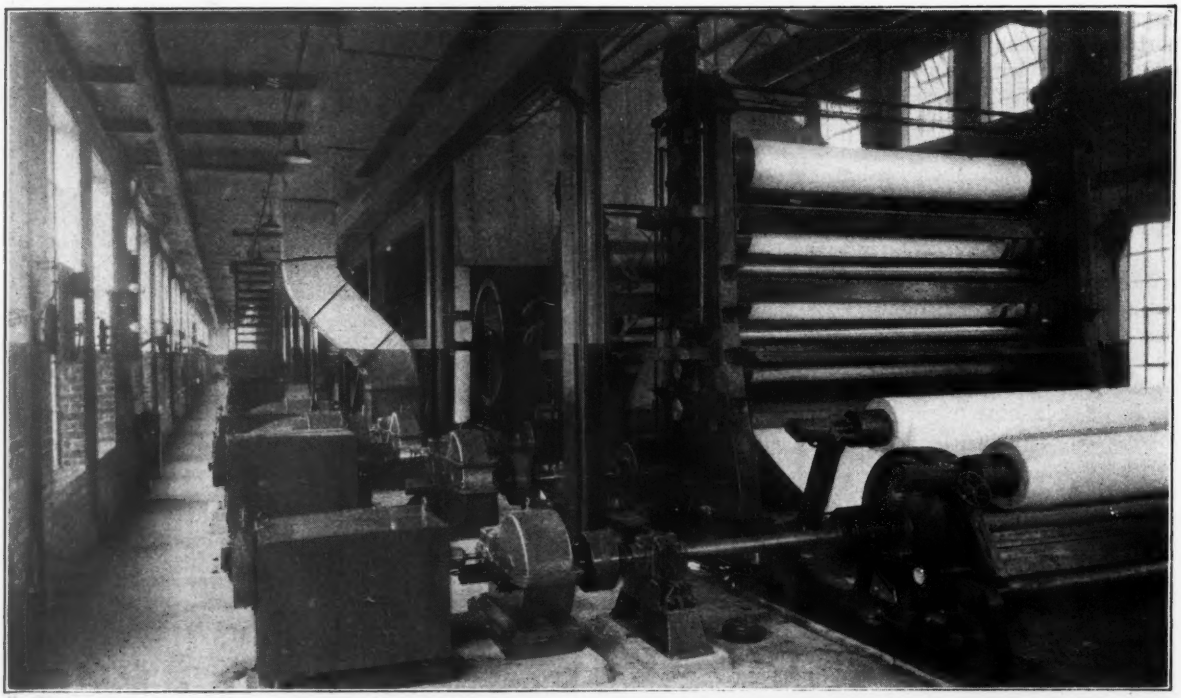


FIG. 1. BACK SIDE OF PAPER MACHINE SHOWS MOTORS AND AUTOMATIC CONTROLLERS

Requirements for Machine 200 Ft. Long

In order to present a clear picture of this problem, a specific case, is discussed—that of a machine which our engineers are now installing for a prominent manufacturer of paper in the East.

This machine, which will produce toilet tissue and crepe towelling, is about 200 ft. in length, Fig. 1, and will make a sheet of paper 178 in. wide and 800 ft. long every minute. The paper will range in weight from 10-lb. tissue to 35-lb. crepe. According to its makers, it is the largest and fastest machine ever built for operation on tissue.

It is driven in seven sections, as follows: 1, Couch roll; 2, 3, Presses; 4, 5, Dryers; 6, Calender; 7, Reel.

Speed of the "wet end," which includes the couch, presses and the receiving dryer, ranges from 170 to 1065 ft. per min. At the dry end the speed range is from 200 to 800 ft. per min. When manufacturing crepe at a paper speed of 800 f.p.m., the wet end must operate at a speed of 1065 f.p.m.

Varied uses to which the machine is to be put necessitate unusual operating flexibility. It must be possible to start or stop the entire machine as a unit; to start

*Chief Mechanical Engineer, the H. K. Ferguson Co., Cleveland, Ohio.

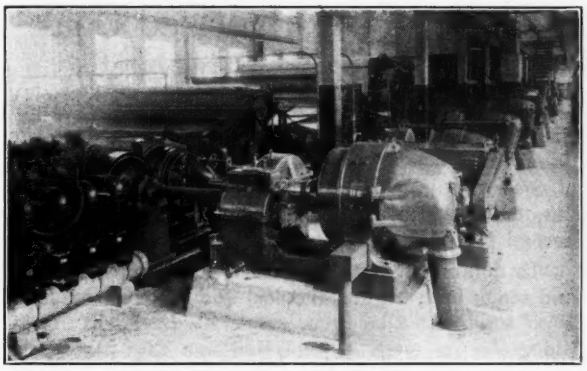


FIG. 2. COUCH OR WET END OF MACHINE WHICH HAS BOOSTER CONTROL

any one section independently of each other section; according to the kind of paper being made, different combinations of sections must be started and stopped independently; the relative speed of the sections must be controlled accurately, as very slight angular displacements are sufficient to break the delicate sheet of wet tissue travelling at a speed of 1065 f.p.m.

Any one of these different operating arrangements must be at the instant command of the operator and automatically-regulated sectional drive has made this possible.

Speed Varied by Voltage on Motors

Power for the shunt-wound, direct-current drive motors is supplied from a turbine-driven generator, operating at 225 volts for a paper speed of 800 f.p.m. Variations of the voltage of this generator from 57 to 225 volts by means of a push-button controlled rheostat produces the required speed range from 200 to 800 f.p.m.

In order to obtain a speed of 1065 f.p.m. on the wet end, Fig. 2, when making crepe, a booster generator, is furnished by means of which it is possible to increase

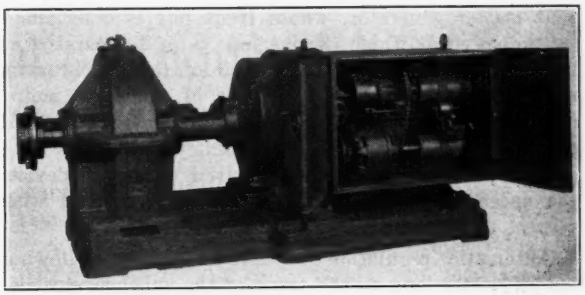


FIG. 3. AUTOMATIC REGULATION IS BY A SYNCHRONOUS MOTOR DRIVEN FROM THE MAIN MOTOR SHAFT

the voltage across the terminals to 300 volts. The operator can increase the speed at will simply by pressing a push button that adjusts a motor-operated field rheostat, which increases the amount of voltage across the terminals to the required amount.

When making straight tissue all the sections of the wet end are connected directly across the 255-volt generator bus by throwing two switches on the control panel.

Automatic Regulators Maintain Relative Speeds

Constant relative speed of all the drive motors is maintained automatically by means of regulators, one of which is furnished for each motor. It is the function of this regulator to vary, automatically, the field current of the direct-current motor to which it is attached. It must respond instantly and smoothly to slight changes in voltage or load. A small synchronous motor, with both rotor and stator mounted on ball bearings, is the main unit of the regulator, Fig. 3. Its rotor is connected through cone pulleys and a flexible chain drive to the shaft of the drive motor. The stator is connected to a rheostat through a chain drive.

Stators of the synchronous motors on all the regulators are excited from a three-phase, alternating-cur-

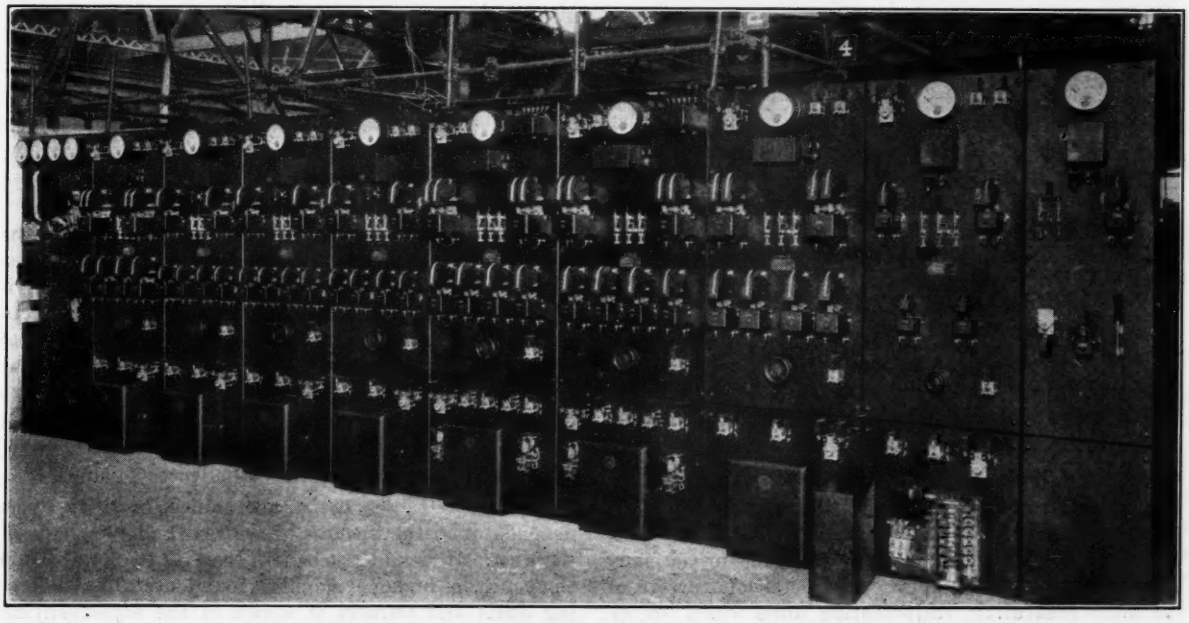


FIG. 4. SWITCHBOARD FOR CONTROL OF GENERATOR, BOOSTER AND MOTOR CIRCUITS

rent master generator, whose frequency is determined by the speed at which the machine is to be operated at the time. The speed of the rotor of the synchronous motor is determined by the speed of the drive motor and the setting of the cone pulleys. By moving the belt to the right or left of the cone pulleys by means of a push-button-controlled, motor-driven shifting device, the speed of the drive motor can be regulated with respect to that of the other drive motors.

Automatic regulation is effected in the following manner: As long as the rotor of the synchronous motor rotates at the same speed as the field of the stator, no torque is produced on the latter and it remains stationary. Should the main driving motor speed up or slow down, causing a corresponding speed change in the synchronous motor rotor, a torque will be produced that will correct the speed difference by moving the stator, thus cutting resistance out of or into the motor field. As the stator moves, it adjusts the brushes of the rheostat, which has 450 fine resistance steps for the regulation of the motor field. The regulator is simple and sturdy in construction. It is subject to little wear, for it is stationary except when load changes demand movement. All adjustments are made by means of push buttons located at convenient stations on the operating side of the machine.

The turbine-generator set, booster generator, master generator switchboard, Fig. 4, and all other equipment except the drive motors and their regulators are located in a room by themselves away from the moisture of the machine room.

Essential Characteristics of the System

Features of the system may be summarized as follows: It provides full automatic control of starting. stopping, slow-speed operation and change of relative speed of the various sections; each drive motor with its speed regulator is a single unit, mounted on a single base; there is no apparatus in the machine room but motors and control buttons: it eliminates the complicated mechanical drive system; because of its extreme simplicity it is inexpensive to maintain. It responds instantly and smoothly to changes of voltage and load. Because of these features it is well adapted to meet the requirements of any industrial drive where similar conditions must be met.

This type of drive has been in satisfactory use in a number of large mills in different parts of the country for several years. The average cost of maintenance is approximately five cents per ton of paper produced, as against 30 to 50 cents per ton for mechanical drive. The first cost of sectionalized drive is higher than that of mechanical drive, but we believe that the difference is justified by the saving in upkeep and by the increased operating efficiency of the motor drive. Illustrations are from photographs furnished by the General Electric Co.

W. E. S. Dyer, consulting engineer of Philadelphia, Pa., who is responsible for the design of the 1800-lb. high-pressure power plant for the Philip Carey Manufacturing Co. of Lockland, Ohio, has gone to Germany in connection with the approval of detail and design of the main generating, reciprocating units which are on order with A. Borsig of Berlin.

Designing Pulverized Coal Ducts and Burners

ONE OF THE greatest obstacles with which the unit system has had to contend lies in designing conduits and burners which will enable the same amount of coal and air to be delivered to each burner, according to John Blizard in a paper presented before the Second National Fuels Meeting of the A. S. M. E.

To obtain the correct mixture and quantity of coal and air at each burner, the coal and air must be mixed

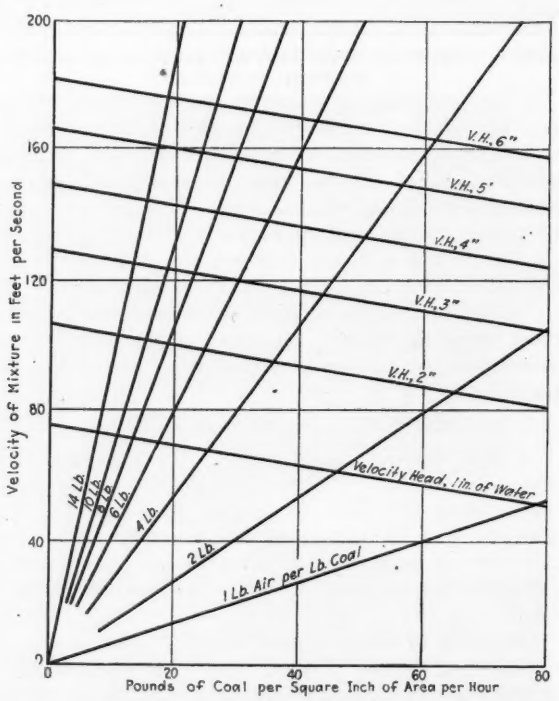


CHART SHOWING RELATION BETWEEN COAL, VELOCITY OF MIXTURE, AND VELOCITY HEAD FOR MIXTURES OF COAL AND AIR AT 200 DEG. F.

thoroughly before subdividing the stream. Where for some reason the mixture is uneven at the point of subdivision, it may be made more even by passing it through a cone converging in the direction of flow. Where space permits, this cone may be followed by a diverging cone to reduce the loss of head.

When the mixture passes through a converging cone the air is accelerated more rapidly than the coal, causing the coal and air to mix. At the point of subdivision, it is common to install a system of dampers to enable the quantities of coal and air to each burner to be regulated as required.

In the conduits conveying the coal and air to the burners, the velocity of the mixture must be maintained in order to prevent the coal and air from separating, since, if this occurs, coal will be delivered in slugs.

Actual velocities to be maintained in these ducts depends upon the fineness of the coal and the shape of the duct. It should not be less than 30 ft. per sec. and commonly is higher. A chart found useful in designing ducts and burners is shown in the accompanying figure.

Heating and Ventilation of Industrial Plants

SYSTEMS AVAILABLE. IMPORTANCE OF TEMPERATURE CONTROL FOR WORKER'S COMFORT. HEAT TRANSMISSION ECONOMY. PROPER HEAT BALANCE. BY EDWARD P. RICH*

IN THIS AGE of keen competition, the success or failure of a manufacturing project is often influenced to a considerable extent by the efficiency of the employes. High standards of personal efficiency are maintained by health and proper working conditions.

In the Northern States, artificial means must be employed to heat, ventilate and, in some cases, humidify

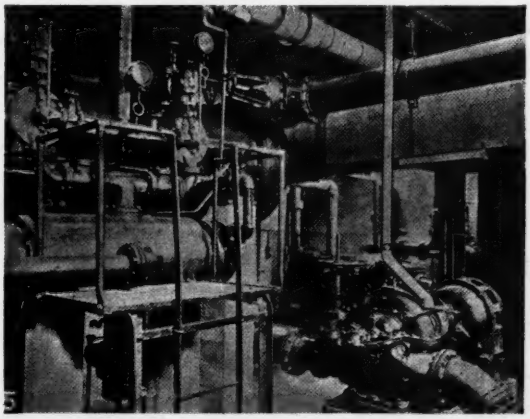


FIG. 1. SURFACE CONDENSER AT AMERICAN SEATING CO. HAS STEAM EXTRACTION FOR PROCESS WORK AND SPRAY POND COOLING

the spaces occupied by factory employes for eight months of the year. Ideal working conditions call for a temperature of approximately 68 deg. F., fresh air free from odors or fumes and a relative humidity of about 60 per cent. Such ideal conditions are not generally maintained in factory heating.

DESIGN OF PLANT SYSTEMS

It is impossible to establish fixed rules to govern the design of heating and ventilation plants for factory use. The arrangement and allotment of the spaces to be served, the number of employes per cubic foot of space and the type and use of buildings are factors which have to be taken into consideration.

Many of the large manufacturing projects started on a relatively small scale and, due to increased business, have added buildings from time to time, the heating system considered a necessary evil, being extended with little thought of adequacy of design or economy of operation.

There are two general types: the factory with few employes and large cubical contents such as large machine shops, car works, foundries and similar industrial plants; and the factory where the contents per capita is low, the employes working at piece work and not physically active. In the former case, low temperatures may be maintained, little ventilation is required and attention should be given to localized heating. Under the latter condition, particular care should be given in maintaining uniform temperature and adequate ventilation.

Failure of the engineer to analyze properly the heating and ventilating requirements may lead to lavish expenditure with resulting economic loss due to heavy overhead on the unnecessary investment, or inadequate design creating an unsatisfactory working condition for the employes.

SYSTEMS IN USE

Three systems of heat distribution are in general use for factory heating. The vacuum system of steam heating, the hot water circulating system and the unit heater system. Each system possesses advantages and the selection of any one of the three or a combination depends upon the general character of the factory and its particular requirements.

VACUUM SYSTEM OF STEAM HEATING

The vacuum system is in more general use for factory heating than any other system or combination. This method of heat distribution has supplanted the

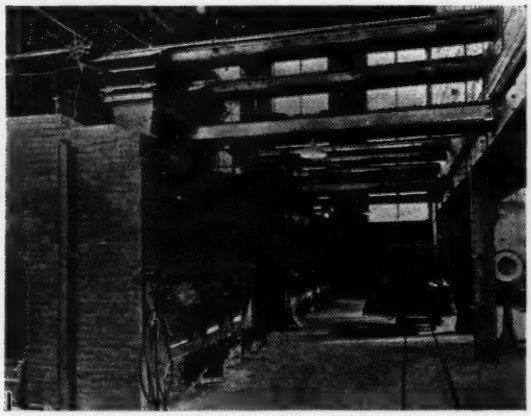


FIG. 2. CONVEYORS BRING SAWDUST TO THE BOILERS FOR A LARGE PART OF THE FUEL SUPPLY

single and double pipe gravity systems. If the piping is properly sized, the radiating surface will be active and can be quickly brought up to temperature.

HOT WATER CIRCULATING SYSTEM

For industrial plants, the hot water system of forced circulation has been infrequently used, although it possesses a number of advantages over the vacuum system of steam heating. The heat loss in transmission is low. By holding the proper relation between the circulating water temperature and the varying outside temperature, overheating of factory space is prevented, resulting in uniform temperature and a substantial steam saving. Although the first cost of such an installation is high, when compared with a vacuum system of steam heating, the operating savings should justify

*Neiler, Rich & Co., Consulting Engineers, Chicago, Ill.

the additional expenditure and a number of large industrial plants in the past few years have been so equipped.

Temperature Control

Few large industrial plants have systems regulated by temperature control. The difficulty of maintaining the pneumatic system under the severe conditions of service found in the factory coupled with the high cost of installation has unfortunately prevented its use.

Systems of individual radiator control, which can be installed at a relatively low cost and require little maintenance, are now available and are worthy of consideration. The hot water system, if properly designed, may be so operated manually as to approach closely the results obtained by thermostatic control, but the vacuum system or the unit heater system must be equipped with controls if uniform temperature is required.

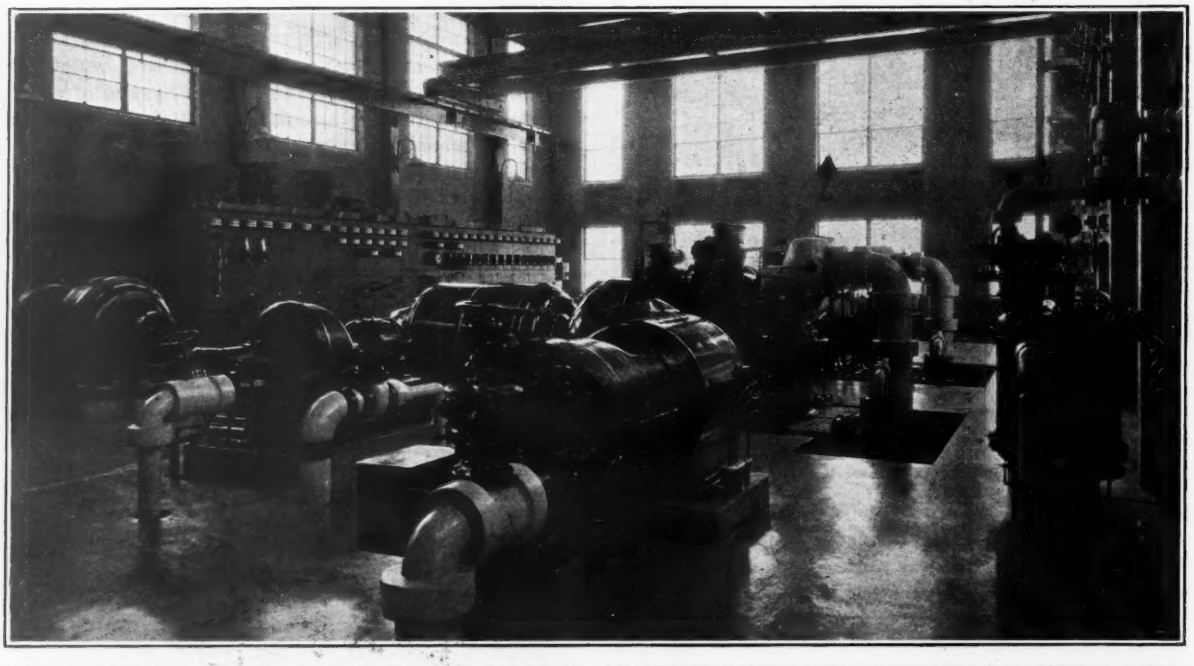


FIG. 3. LEONARD DIVISION OF THE KELVINATOR CORP. AT GRAND RAPIDS USES CONDENSING TURBINES WITH EXTRACTION STEAM FOR KILNS AND HEATING, TAKING A LARGE PER CENT OF THE STEAM

Unit Heaters for Factories

Factory heating by means of hot air has gradually changed in the past decade from the central fan type, which consisted of centrifugal fan, steam coils and duct distributing systems, to unit heaters, each being a complete, self-contained heating unit. These units are located at points required to give the proper distribution of the heated air to all parts of the building. The number of units used depends on the type of building as to shape and construction and the maximum B.t.u. demand.

The unit heater may be used to heat large spaces, by recirculating the air through the heater coils, or can be connected to the outside and used for introducing fresh heated air into the building where ventilation is required. Under certain conditions, a combination of direct radiation to care for building loss and of unit heaters installed for ventilation makes a satisfactory installation.

From the standpoint of economy of steam and even distribution of heat, the best arrangement is to have the units so located that the cold air can be drawn from the floor, heated and discharged into the room 8 to 10 ft. above the floor line. By such circulation of air, the heat supplied to the room is held more effectively in the region of occupancy, instead of rising to the ceiling or roof line where the heat is of little value.

Where floor space is at a premium and cannot be given up for heating apparatus, the units can be suspended from the ceiling or trusses. If the building is high and of such shape that air currents can readily rise to the roof, the heating capacity of the units must be increased.

Although a great number of different makes and designs of units are in use, all can be classified in two general groups, the one employing a propeller type fan, the other using a centrifugal type fan to handle the air. The first type operates on low air velocities with less horsepower consumption per 1000 cu. ft. of air handled. The low velocity unit is better adapted to buildings where the heated air is to be carried but short distances and, to effect the best distribution, units of small capacity should be installed. The second type, which discharges the air at high velocity and with greater carrying force is best adapted for large spaces. Fewer units are necessary as 1,000,000 B.t.u. can be supplied by one unit heater, and perfect distribution obtained.

Air Conditioning

Air conditioning, which is a term used for the proper maintenance of humidity, is used extensively only where it is essential to maintain an even humidity for special manufacturing processes. The installation cost of this equipment is high and, for general factory heating and ventilation, the control of humidity should be accomplished by simple, inexpensive means.

For transmitting heat from the power house to the point of use, the method employed depends upon the particular system used for heating the factory. If low-pressure steam is available and a vacuum system is installed, the transmission can be taken care of by an extension of the supply and return lines. Steam can be carried easily for 5000 ft. with 1 lb. pressure maintained at the power house and 7 or 8 in. of vacuum at

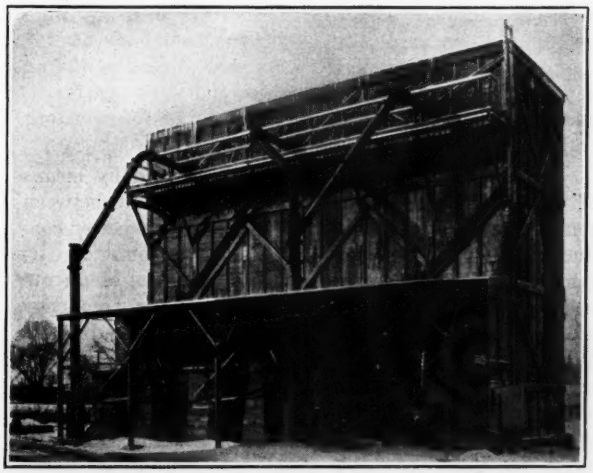


FIG. 4. THIS COOLING TOWER SERVES THE TURBINES AT THE LEONARD PLANT

the pumps, provided that the pipes are properly proportioned.

If the system of heating is hot water, the converters can be installed in the power house and the hot water circulated through supply and return mains, or the heat generators can be placed in the building to be heated, these generators being supplied by either live steam or low-pressure steam as conditions require.

Transmitting High Pressure Steam

For plants where exhaust steam is not available, a system of high pressure transmission can be installed to advantage. An initial pressure of from 80 to 100 lb. can be maintained with steam velocities, under maximum load conditions, as high as 12,000 ft. per min. By maintaining high velocity, the pipe sizes can be reduced to a minimum with resulting low cost of initial investment and small radiation losses. The pipe sizes must be properly proportioned so that the drop in pressure under maximum load will give sufficient terminal pressure in the branch lines. Reducing valves can then be installed in each building, with connections made directly to low-pressure distributing mains. This system of distribution permits of the use of high-pressure steam for process work in the factory.

Construction of Transmission Lines

Local conditions dictate, to a considerable extent, the design of the transmission line. The ideal method is to install the piping in a tunnel of sufficient size to permit of inspection and repairs. A properly constructed tunnel is expensive, running in the neighborhood of $60 per foot of length. In many plants, short runs of tunnel can be installed and the balance of the transmission carried in the factory spaces, in this way cutting down on the initial investment.

In some cases, overhead lines properly supported by steel or wood structures work out in a satisfactory manner, although it has the disadvantage of obstructing the passage through factory grounds and requires continual attention in the maintenance of supports and covering.

In many factories, underground installations are made of split tile conduit. If properly constructed, this system is reasonably satisfactory but represents a certain hazard on account of the fact that careful inspection cannot be made of the pipe or pipe insulation. A system of this character can normally be installed at about a third of the cost of a well constructed tunnel system.

For long transmission lines, where possible, the use

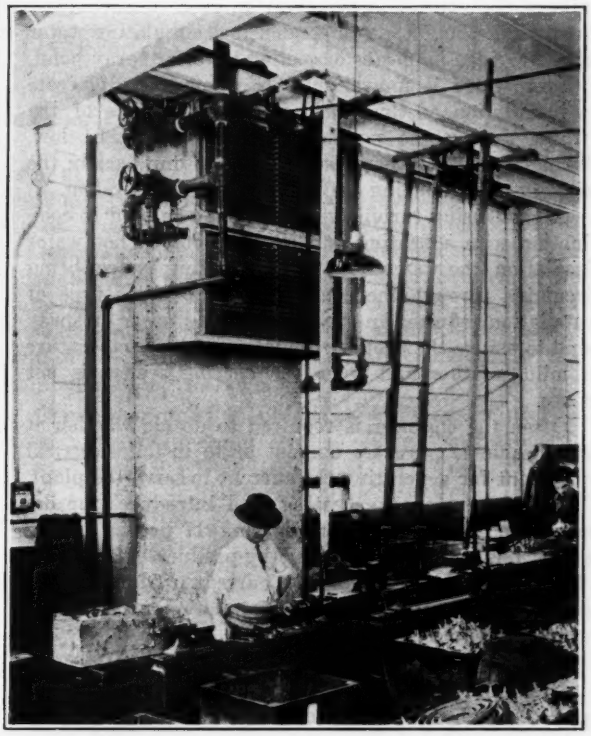


FIG. 5. UNIT HEATERS ARE USED TO SUPPLY HEAT AND VENTILATION BOTH SUMMER AND WINTER

of bends is recommended to care for expansion. In recent years, welding has been used to replace couplings or flanges. A welded pipe line, which has been constructed by experienced labor, presents many advantages and reduces the maintenance charges to a minimum.

Steel pipe used for steam transmission appears to be entirely satisfactory and, generally speaking, little trouble will be experienced with corrosion. For return lines or lines carrying condensate, deterioration of steel pipe is sometimes rapid and genuine wrought iron pipe is recommended on account of increased life.

Heat Balance of the Plant

Each plant has its own particular requirements for steam and electrical energy. In many cases, the heating load is sufficiently large to affect materially the economy of plant operation.

In plants where the power demand is heavy and the

heating load light, in general, the extraction of steam for heating from the main electrical generating units is inadvisable. In this case, steam-driven auxiliary equipment such as boiler feed pumps, vacuum pumps and air compressors, operated noncondensing, can be used to serve the heating system, high-pressure steam through reducing valves supplying any deficit.

In plants where the heating load constitutes a large percentage of the total boiler load required by the prime movers used for electrical generation, there are opportunities of making substantial savings by properly taking account of the heat balance.

As an example, in the furniture industry, wood waste is available for fuel, the heating and kilns call for large boiler capacity and the electrical power loads are relatively small. In plants of this character, turbine units of the extraction type can be used to advantage. The turbine should be run condensing, circulating water being provided by means of cooling tower or spray pond, if river water is unavailable. Economy results from an installation of this kind, as the water rate of the turbine during the non-heating periods will be low. During the heating periods, the turbine units act in the capacity of a reducing valve for the heating system.

A condensing turbine generator may be used in combination with a heating system using forced hot water circulation, the water used for the heating system being circulated through the condenser tubes. This type of installation requires an auxiliary cooling tower or spray pond to assure the proper circulating water temperature in mild weather and when the heating system is not in use.

Often the engineer is required to decide whether it is advisable to purchase current or to install electrical equipment for generating the current to serve the plant.

In many cases, the heating load introduces the determining factor in the comparison. If proper advantage is taken of this load and by-product steam used, a low rate per kilowatt-hour for current production may result, which will justify the installation of electrical generating equipment.

Resume

It has been impossible, in this short article, to dwell upon the many important details of arrangement and design required in a comprehensive system of heating and ventilation for the factory but the writer has endeavored to bring forcibly to the attention of the executive and engineer the essential factors of economic value.

The experienced engineer can determine the comparative initial and operating costs of the several combinations of heating and ventilation, which may be under consideration, with reasonable accuracy. But the intangible gain, due to increased personal efficiency of the employes under proper working conditions, can be only approximated.

On account of the high cost of skilled labor, it would appear that substantial returns are possible due to increased personal efficiency brought about by improving the working conditions in the average industrial plant.

Brain and body work to best advantage when the worker has personal comfort. Equitable temperature and pure air are essential to health and contentment. The heating and ventilating problems of your factory should receive serious consideration and a careful study.

Ore Finding by Electricity

TO DETERMINE the presence of metallic ores in the ground, the Radiore process has been developed by a research of E. H. Guilford and J. J. Jakowsky, who have followed up attempts of A. B. Menefee and H. E. Olund. Results of the attempts of the latter to use radio were encouraging but, in some respects, were inconsistent with known facts as to ore locations.

Substitution of a coil system for the original radio antenna and ground, decrease in the frequency of current used and development of a new direction-finding device solved the difficulties so that the perfected method functions equally well in all kinds of territory and under any climatic conditions.

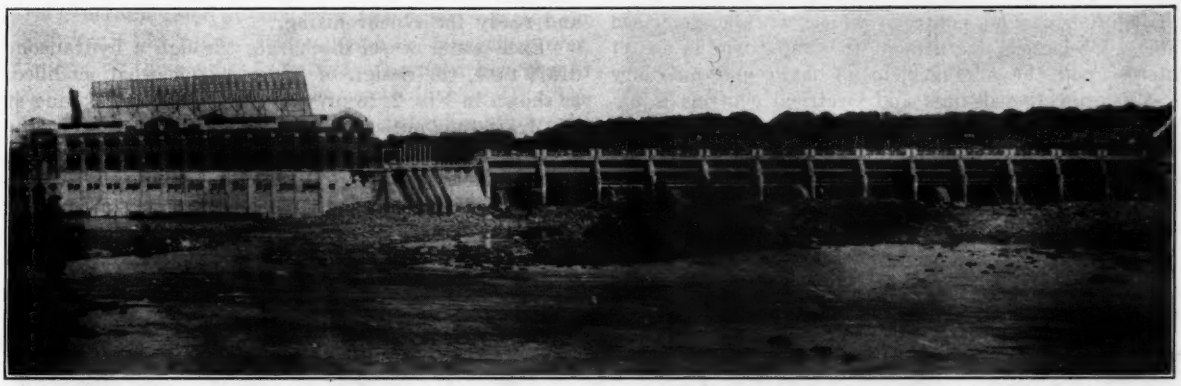
Setting up an alternating magnetic field by means of the coil, induction causes current to flow between conductors underground. Ores of metals are better conductors than rocks or earth so that the amount of current flowing will be affected by the presence of an ore body, the effect depending on the type of ore, frequency of current and relative conductivity of ore and earth. Where broken or faulted ore veins are encountered, frequencies as high as 40,000 cycles per second are used to cause an appreciable current to flow.

Clear indications are secured only when the ore is about 100 times as good a conductor as the surrounding earth but it is not uncommon to find ores 10,000 times as good conductors as the earth.

The magnetic field set up surrounding a conductor will pass through rock and earth. To locate the ore-conductor, it is necessary to determine, on the surface of the ground, from which direction the magnetic field comes. For this purpose, a vacuum-tube apparatus with direction coil, somewhat similar to the shore radio stations for determining the direction from which messages from ships at sea are coming is used. The coil works in a vertical plane and, by moving it and noting the changes in signal strength, direction of the ore body can be determined. Because of complications of the electric and magnetic effects due to passage of waves through air, earth and ore, skill and experience are needed for competent determinations.

Results for 2 yr. have proved the general utility of the process and location of ores within 250 ft. of the surface is generally accurate within 10 per cent, which is sufficient for ordinary purposes. Research and improvement are being continued but the method will not lessen the importance of the mining engineer and geologist. Rather it will become a scientific tool for their use to reduce the speculative element in prospecting and mining.

MUSCATINE, IOWA, municipal light plant recently purchased the Muscatine Lighting Co., subsidiary of the United Light and Power Co. with distribution system in the city of Muscatine under contract which provides that the utility corporation cease operating as distributor and seller of current, March 1, 1929. The contract price was $73,924.28, the appraised valuation of the system. By the purchase, the municipal plant acquires 1,293 meters now in use but the sale did not include meters in stock, high tension lines or the substation.



Adjustable Propeller Runners at Chippewa Falls

RECENT INSTALLATION OF NORTHERN STATES POWER CO. INCORPORATES LATEST DEVELOPMENT IN WATER WHEEL DESIGN, TOGETHER WITH INTERESTING ELECTRICAL AND CONTROL FEATURES

HYDRAULIC ENGINEERS are much interested at the present time in the use of the propeller type hydraulic turbine, especially the type in which the angle of the vanes may be varied to maintain efficiency as the head or the load on the turbine varies. Of the several recent installations of this type of runner, the generating units at the new Chippewa Falls plant of Northern States Power Co. on the Chippewa River in Wisconsin have attracted much attention.

This station, shown in the headpiece, was placed in operation in 1928 and has a total capacity of 27,000 kv-a. at 0.8 power factor or 21,600 kw., in six generating units. The station is located about 2 mi. downstream from the Wissota hydroelectric development of the same company. It operates in conjunction with the Wissota plant; that is, since Wissota must first use the water that passes through Chippewa Falls, the method of operation is dictated by the load and by water conditions at Wissota because there is no pondage in the Chippewa Falls reservoir.

Generating units at Chippewa Falls are controlled entirely by one operator from a central control board,

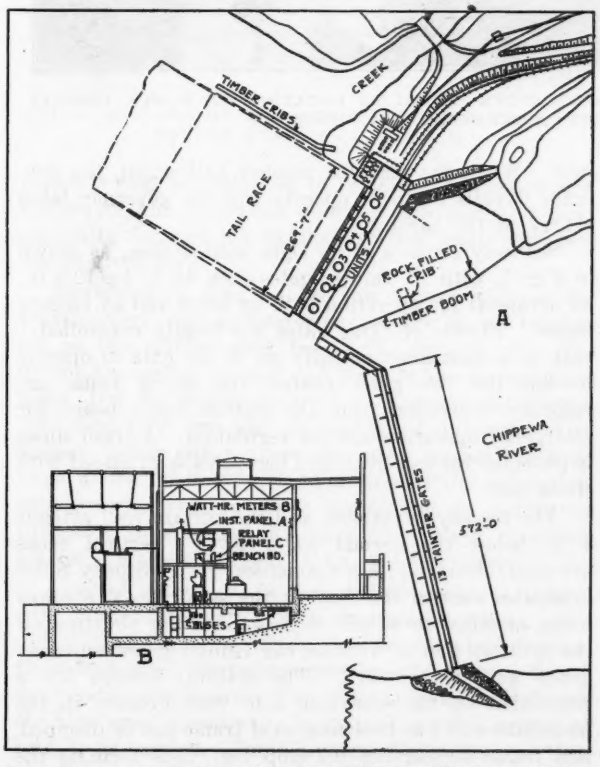


FIG. 1. A—GENERAL PLAN OF DEVELOPMENT AT CHIPPEWA FALLS. B—GENERAL CROSS-SECTION THROUGH POWER HOUSE SHOWING CONTROL ROOM

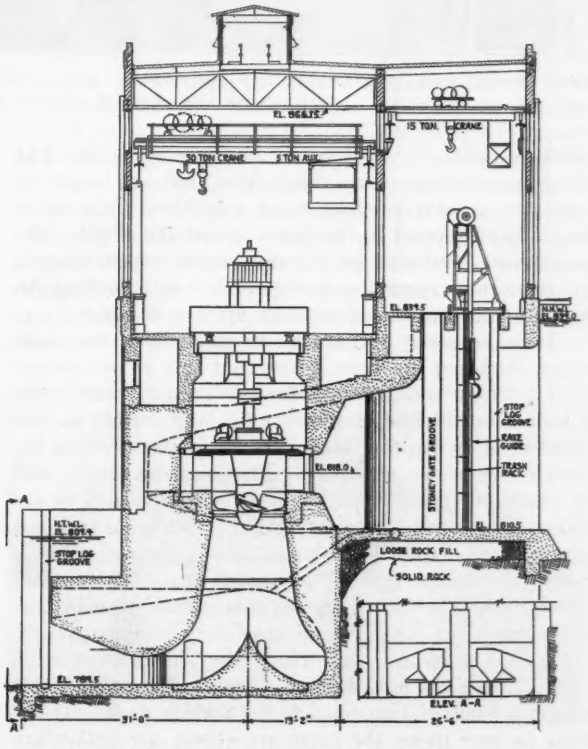


FIG. 2. CROSS SECTION THROUGH GENERATING UNITS, AND HEADWORKS. ELEV. A-A: END VIEW OF ONE DRAFT TUBE

assisted by a floorman whose only duties are to inspect the equipment and controls, which will be described later. Mechanical features of the water wheels are of interest and the arrangement of main and auxiliary busses, protective devices and electrical controls is unusual in many ways.

As shown in Fig. 2, the water wheels are of the adjustable vane propeller type. They are Allis-Chalmers 5000-br.hp. units operating under a maximum head of 29.6 ft. at 138 r.p.m., specific speed 140. Each runner has four vanes, the angle of which is adjusted to meet varying water conditions by a mechanism incorporated in the large hub of the wheel. This mechanism, actuated by a hand-turned socket wrench, is simple and rugged and is provided with locking devices to preserve the adjustment after it is made.

It is necessary, of course, to shut down the units when changing the vane setting but this is not considered a serious disadvantage for two reasons: first, when a unit is on the line, it operates for long periods at constant head or constant load, because of the relations between the water conditions at Chippewa Falls and Wissota and these conditions can be determined in advance; second, the entire operation of changing the vane setting takes only about 5 min. and since the plant is part of a large system, it would cause little inconvenience to shut down one unit at a time to make the adjustment, in case it were absolutely necessary.

As the units are started and stopped automatically, the operator has only to push the stop button, take his socket wrench and go down to the turbine deck. By the time he gets there, the gates are closed, air brakes are automatically applied, all electrical connections are opened and the unit is at rest. He then makes the vane adjustment, goes back to the control board and pushes the start button, which brings the machine up to speed and ready for synchronizing.

Each water wheel discharges through a hydraucone draft tube, the design of which is somewhat modified, as shown in Fig. 2, to prevent turbulence and boiling at the draft tube outlet.

Allis-Chalmers oil pressure governors are used, with motor-driven flyballs. The motor driving flyballs is energized from the generator itself when starting the unit. When the machine reaches half speed, the governor flyballs begin to operate and the governor takes charge of the turbine.

FIG. 3. GENERATOR FLOOR AT CHIPPEWA FALLS IS ATTRACTIVE OWING TO LOCATION OF PUMPS, CIRCUIT BREAKERS AND OTHER AUXILIARIES ON TURBINE DECK BELOW

Spillway consists of an Ogee section dam, as shown in Fig. 1, with 13 Tainter gates each 40 ft. by 12.5 ft., all arranged for operation both by hand and by electric motor. Eleven of these gates are locally controlled—that is, a man must actually go to the gate to operate it—but the two gates nearest the power house are remotely controlled from the station bench board for emergency operation and for regulation. A trash sluice is provided for ice, trash and logs; this is equipped with sluice gate.

The forebay is covered, and the curtain wall extends 4 ft. below the normal water level. Vertical racks are used, cleaned with a mechanical rake. Stoney roller headgates control the flow to the scroll cases, a crane being installed to handle these gates. For shutting off the spillway flow to work on the Tainter gates, an emergency gate is provided. The spillway section has a projection on the upstream side with grooves in the piers into which a structural steel frame can be dropped, this frame supporting the stop logs, thus forming the emergency gate. Compressed air is used for preventing ice; air bubblers are placed in front of the forebay wall and all along the dam.

Each of the six water wheels drives a General Electric generator rated at 4500-kv-a. at 0.8 power factor (or 3600 kw.) 138 r.p.m., 4000-v., 3-phase, 60-cycle power. Control of these units is entirely from the benchboard in the control room, located as shown in Fig. 1B. The indicating meters are on panel A suspending from the ceiling, while panel B carries the watt-hour meters and recorders. Panel C, on the floor bebind the board, is the relay panel. All wiring is thus accessible and the arrangement has proved most convenient for the operators.

One of the most interesting features of the plant is the arrangement of buses and electrical equipment. Two buses run the entire length of the power house, suspended below the generator floor in the space between it and the turbine floor. These buses are of box construction, Fig. 4, in six strips, one strip being dropped at each unit. They are enclosed in a sheet steel casing that permits ventilation and at the same time fully encloses them.

Buses are held in place by clamps, as shown, and are assembled in sections with loose leaf expansion joints between the sections. As the buses are 310 ft. long, this provision had to be made for expansion; the scheme has the further advantage that it enables the bus to be firmly clamped together in sections before erection and

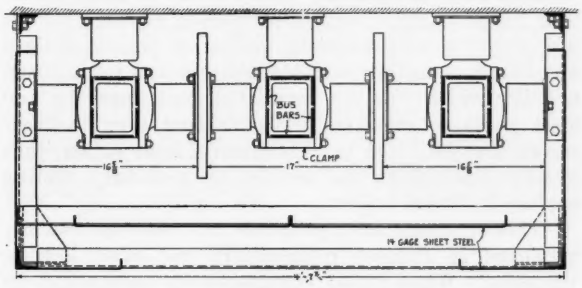


FIG. 4. DETAILS OF THE BOX TYPE BUSES THAT RUN ENTIRE LENGTH OF STATION

makes it easy to install or to remove for maintenance. Details of the expansion joints which were designed especially for this job by the electrical engineers, cannot be given here.

Switching is done on the low tension side of the transformers; each generator has its own circuit breaker set on the turbine deck beside the turbine pit. The double bus system is used and there is also an auxiliary 230-v. bus for auxiliaries such as governor oil pumps. This auxiliary bus may be energized through transformer banks either from the main station buses or from a line leading to the Chippewa Falls substation, thus assuring outside power supply for the auxiliaries necessary in starting the machines. Each generator carries a direct-connected 50-kw. 250-v. exciter.

Control equipment is designed for manual control with automatic starting and shutdown features. The operator at Chippewa Falls receives complete instructions from the Wissota operator by telephone or by remote indicating devices. The Wissota operator indicates the number of machines to be started and the amount of load to be carried. The Chippewa Falls operator then ties in the upstream bus with the Wissota transmission line through an oil circuit breaker and notifies the floor-

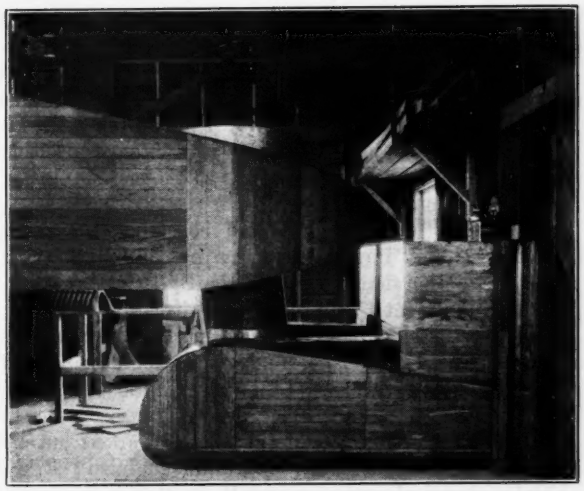


FIG. 5. MODEL OF SCROLL CASE AND DRAFT TUBE FORM, SHOWING MODIFICATIONS IN DRAFT TUBE

man to inspect the unit. When the floorman has done this, he signals the operator at the benchboard to proceed. The latter then closes the generator field switch and cuts out enough resistance in generator and exciter fields to assure the starting of the governor flyball motor when the unit reaches half speed.

Next the operator pulls the starting switch, energizing a relay that closes the solenoid on the automatic governor control mechanism. This circuit is made through several protective devices: two emergency stop switches (one on the benchboard and one on the floorman's control panel), an overspeed device, four bearing thermal relays, a low-pressure oil switch and a multicontact direct current relay connected to the differential, low-energy alternating-current relays. If any one of these devices is open, the unit cannot start or if one of them opens during operation the unit will shut down.

Energizing of the governor solenoid causes the wicket gates to open and brings the turbine up to speed at a rate determined by an adjustable rate limiting device on the governor mechanism. When the machine is up to speed, riding on the governor and normal voltage obtained, the operator synchronizes the unit and loads the machine. The neutral point of one of the machines only is to be grounded during operation of the station and all the neutral breakers are interlocked so that only one of them them can be closed at any time.

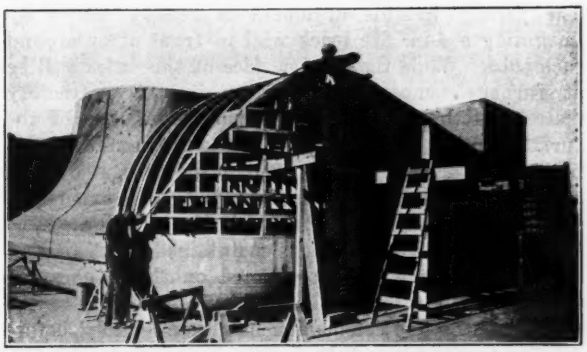


FIG. 6. BUILDING THE FORMS FOR ONE OF THE HYDRAUCONE DRAFT TUBES, FOLLOWING THE LINES OF THE MODEL

During operation, the units are protected by relays against overspeed, hot bearings, low governor oil pressure, differential fault, or loss of field excitation. The operator or floorman can stop a machine at any time by pulling one of the emergency stop switches, which causes the gates to close, locks the gate latch in position and trips out the main breaker. This method is for emergency shutdown only.

The plant was designed and constructed for the Northern States Power Company by the engineering and construction departments of the Byllesby Engineering & Management Corp., under the direction of H. W. Fuller, vice-president in charge of engineering and construction, and F. H. Lane, manager of engineering and construction. J. Wm. Link, hydraulic engineer, and H. W. Eales, chief electrical engineer, were in charge of the design, the details being worked out by Stephen Wehner, assistant hydraulic engineer; E. N. D'Oyly, electrical engineer, and H. L. Hoeppner, assistant electrical engineer. The construction was under the direction of W. T. Walker, superintendent of construction, assisted by W. H. McArthur, resident superintendent of construction.

Aiding Boiler Heat Absorption

WIDER TUBE SPACING WITH BAFFLES TO PROMOTE HEAT RADIATION. BY B. W. DENNIS*

MODERN TREND in boiler design seems to be toward as great an amount of radiant heating surface as it is possible to obtain. This is accomplished by the use of water walls with or without finned tubes and radiant heat superheaters, thus rendering unnecessary a large amount of rear bank tube surfaces to receive their heat from the gases by convection.

Inasmuch as these radiant heat surfaces are producing the larger portion of steam in boilers of the latest type, they should be maintained in clean condition, both inside and out. Modern design, in these larger plants especially, is using evaporators for obtaining distilled makeup water, thus maintaining the inside of the tubes at highest efficiency. Concerning necessary cleanliness of the outside of tubes, there seems to be a mistaken idea. Some engineers maintain that, no matter how badly slagged or caked with soot the outside of tubes may be, they believe that this outside foreign material, being at the temperature of the gases on its outer surface, conveys this temperature to the tube. The fallacy in this argument is readily shown by imagining a 4-in. fire brick wall in front of or around each tube. While the furnace face of this brick will be at furnace temperature or near it, this refractory material does not attain the high temperature of the furnace on the side next the tubes and, therefore, cannot radiate or conduct heat well to the tube.

On the other hand, it has been proved by experience in large boiler operation, that, if the exterior of the furnace or first row tubes is maintained in clean condition, slagging will be prevented on those tubes immediately following in the path of gases, due to the fact that complete combustion has been obtained before passing to the upper tubes.

If, however, the foreign material be separated from the tubes and allowed to become heated through by convection or radiation from the gases or furnace, then effective reradiation will occur from this foreign substance to the tube.

In a recent statement, Professor W. Trinks says that, "If a flue carrying hot gases through a boiler is provided with a central core of refractory material, the latter becomes hot and radiates (meaning reradiation as expressed above) all the heat which it receives from radiant or convected heat of the furnace or gases directly to the flue. The surface of the core has become additional heating surface. This shows a way in which radiation can be used to improve boiler absorption."

This quotation is speaking of fire-tube boilers. If we extend this same principle to modern water-tube boilers, we may install say 2-in. thick refractory tile in rows parallel to the flow of gases, thus guiding the gases between the tubes and radiating the absorbed heat as radiant heat to the first-pass tubes, increasing their efficiency and requiring that much less heat be absorbed by large numbers of back-pass tubes, placed in tortuous gas passages and likely to be inefficient.

These radiant heat walls, which will reradiate their heat to the tubes, may be cleaned from soot and slag by properly placed blowers with comparative ease. While this type of boiler would be somewhat of a departure from present day practice, the writer believes that the adoption of such tube spacing as will allow its use, would not be a serious matter in present designs and that it is entirely possible and practical to construct a boiler which will use reradiated heat from tile and steel guide or partition walls, so that even the rear passes may be aided by this form of heat action, thus greatly diminishing the amount of secondary heating surface in future boilers.

This reradiant heat principle has been successfully employed in furnace recuperators and other heating processes. When boiler manufacturers understand its success in these other fields, they will surely be willing to adapt their designs to allow a fair trial of this practice in boiler operation.

*President, Dennis Engineering Co., Columbus, Ohio.

CONTRACTS have just been let by the Tennessee Electric Power Co., Chattanooga, Tenn., and its subsidiary the Nashville Railway & Light Co. for the construction of new substations and new transmission lines at an estimated cost of approximately $1,500,000. These transmission lines will run east and south from Nashville through Centerville to Hohenwald and from Centerville north to McEwen. Of this extension 58 mi. will be steel tower construction of which 14 mi. will be double circuit. There will be 51 mi. of wood pole construction. The conductors throughout these transmission lines will be aluminum steel core with copperweld cable used as a ground wire. These contracts include the construction of four new substations located as follows: One in Nashville, one in Centerville, one in McEwen and one in Hohenwald. It will be necessary also to enlarge the existing South Substation in the city of Nashville. This construction work is being carried out by Stevens & Wood, Inc., Nashville and New York, who are also doing the purchasing. Work of clearing some of the rights-of-way has started. Material is being purchased and the schedule calls for these transmission lines and substations to go into service during the summer, 1929.

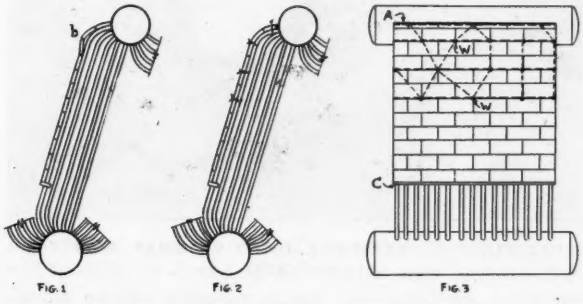
LETTERS DIRECT FROM THE PLANT

Wired Baffles Do Not Warp

BAFFLE BRICK over the second bank of tubes in our boilers has given trouble. We had to replace the brick every time we took the boilers off the line. The tubes are nearly vertical on this type of boiler and are curved near the top. Baffle brick, 12 by 12 by 2 in., rests on clamps fastened to the tubes as shown at C in Fig. 3.

By the expansion and contraction of the tubes, the baffle brick was loosened and would buckle up, as shown in Fig. 1 at b where the lower end of the bend in the tube begins.

At first it was thought that we had not provided for expansion next to the upper drum. We therefore left



BUCKLING OF BAFFLE BRICK PREVENTED BY WIRING IT TO TUBES

1½ in. space between the drum and top of the baffle brick but this did no good. The chief figured on buying a different type of baffle brick but, as we had a lot of new brick on hand, the loss due to scrapping this brick would have been considerable, so we tried again.

Obtaining some bale wire, we wrapped pieces of it around the tubes, allowing both ends of the wire to stick above the brick, spacing the wires 2 ft. apart to a point halfway down the baffle wall, where most of the trouble started. Then we laid down the baffle brick and cemented the joints. Wires were stretched across each brick in both directions and twisted, as shown in Figs. 2 and 3 at w, the wires crossing the top of the brick being indicated by dotted lines in Fig. 3. A 1-in. space, left between the brickwork and drum, was filled with asbestos, as shown at A in Fig. 3.

Since making the change described above, we have had no trouble with the baffle brick. Some men laughed at the idea at first, saying "the wires will burn off," but we have had the boilers running at 250 per cent rating and they have been in service over 8 mo. since the change was made. The wires are still holding and a considerable amount has been saved in repair cost by the simple procedure outlined.

Akron, Ohio. ANTHONY PULLEKINS.

Dollars Loss from Air Leakage

ANOTHER APPEAL to engineers for presenting the sum totals of their talks to their superiors in the language of dollars and cents, which was published on page 1059, Oct. 1 issue, interested me. Too many of our problems end with a percentage sign and are pigeon-holed because of inadequate information of the kind those who pay the bills understand.

In a previous position, a particular instance of this kind came before me when the repair of boiler settings, which had cracked so badly at the sides and top as to admit a great deal of air, was discussed. My supervisor knew, as I did, that the yearly loss exceeded the cost of repairs but as all accounts here were budgeted, it was necessary to file an estimate of the savings in order to get an appropriation of money for repairs.

To estimate the loss of fuel by air infiltration through the settings and present it in dollars and cents form, I arranged a ¼-in. sampling pipe through the furnace wall and plugged the end. Eighth-inch holes were staggered on opposite sides of the pipe at about 5-in. centers. The end of the pipe extended about 30 in. into the combustion chamber which I thought would give a fair sample of gas before any air had filtered in. The regular sampling tube was in the uptake below the damper and consisted of ¼-in. pipe plugged and drilled as previously mentioned but this pipe extended the full width of the uptake. In order to get actual conditions, it was necessary that readings be taken from both places at the same time, so I used my Orsat apparatus on the furnace connection and had an assistant inflate it by means of a hand aspirator with the gas from the uptake connection.

From the two connections, the analyses obtained were as follows:

	Furnace Connection	Uptake Connection
CO_2, %	11.8	10.2
O, %	6.4	8.2
CO, %	0.0	0.0

Uptake temperature, 540 deg. F.; boiler room, 80 deg. F.

With this information, I used the formula for finding the heat loss in flue gases per pound of fuel, which is, $L = 0.24\ W\ (T - t)$, in which 0.24 = the generally accepted specific heat of flue gases; W = the weight of gases formed per lb. of fuel; T = temperature of outgoing gases; t = temperature of incoming air or boiler room temperature.

Before this formula could be applied, it was necessary to find the value of W. In the formula $W_1 = [11\ CO_2 + 8\ O + 7\ (CO + N)] \div [3\ (CO_2 + CO)]$, W_1 equals the weight of gases formed per pound of carbon burned and this, multiplied by the percentage of

total carbon in the coal, supplies the value of W in the first formula. From ultimate analysis, the percentage of carbon in coal was 76.

For the furnace connection, $W_1 = [(11 \times 11.8) + (8 \times 6.4) + 7\ (100 - \{11.8 + 6.4\})] \div 3\ (11.8 + 0) = 21.3$ lb. This times $0.76 = 16.2$ lb. gas per pound of dry coal, or W.

$L = 0.24 \times 16.2\ (540 - 80) = 1788.5$ B.t.u. per pound of dry coal.

By the same process, loss in flue gases in the uptake works out, $L = 2046.8$ B.t.u. per pound of dry coal.

The loss due to air leaks is the difference between the B.t.u. loss in each case, $2046.8 - 1788.5 = 258$ B.t.u. per pound of fuel of heat value 14,213 B.t.u. per pound. Then, $258 \div 14{,}213 \times 100 = 1.8$ per cent lost by air infiltration.

Each boiler used about 1080 t. of coal annually at $4.95 per t., hence $1080 \times 0.018 \times 4.95 = \$96.23$ per year loss. It cost $84 to repair a battery of two, hence $84 \div 2 = \$42$ per setting. Then $96.23 - 42 = \$54.25$ per year saving on one boiler.

Keyport, N. J. GEO. B. LONGSTREET.

Boiler Feed Made Continuous with Bypass

OPERATION of a small, isolated and overloaded steam power plant in a flour mill was found to be considerably hampered by the boiler feed. The feed pump was too large and, forcing a large volume of not very warm water into the boiler at frequent periods, brought down the steam pressure during those periods in spite of all attempts to keep it up.

Trials were made to throttle down the pump until it could be run continuously, slowly enough to deliver just the amount of feedwater required. But the steam pump proved to be somewhat worn, hence required too much steam. The injector would not operate when throttled low enough to provide a continuous flow of feed water as required. A smaller injector was borrowed and tried out with unsatisfactory results, owing to the necessity of using the steam pump under heavy steam demands, when the small injector failed to supply the amount of water required.

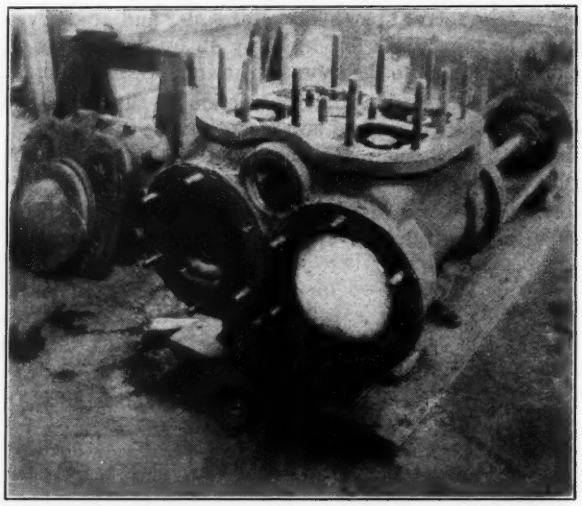
Arrangements were then made so that, by opening a stop valve, water could be bypassed around the pump from discharge back to supply. By adjusting this valve, part of the water was allowed to bypass, the remainder being forced into the boiler. This arrangement resulted in steady boiler feeding, even for light loads, but steam was wasted in doing useless work.

In order to reduce this waste, an unused belt-driven power pump was substituted for the steam-driven pump. It was put into condition, fitted with tight and loose pulleys and driven from the mill shafting at a speed sufficient to take care of maximum demand. Bypassing with valve regulation was employed as before but, while wastage was reduced, trouble was experienced in the scoring of the bypass valve due to throttling. Instead, therefore, of partly closing the bypass valve, three openings were arranged, each supplied with a stop valve and having openings which were bushed down to different sizes. In operation, one or another of these valves would be completely opened, the bushed orifice providing reduced flow. A fourth opening was fitted with an adjustable garden hose nozzle, to provide a ready control for minor changes in the rate of feeding.

Indianapolis, Ind. JAMES F. HOBART.

Undrained Water Causes Damage in Winter

OIL AND WATER will not mix, not at least within the experience of the average layman. Water and cold weather, however, reach an agreement with a suddenness which would gladden the heart of many a labor arbitrator. We reproduce a photograph of an ice-filled cylinder both as a reminder and a warning; a reminder



ICE FILLS UP CYLINDER OF PUMP THAT WAS NOT DRAINED

not to forget that the season of cold weather will soon be upon us, when the battle of wits between the engineer and Old Man Winter will be on in earnest; a warning that drain cocks and valves at this season of the year need as much careful attention as the indicator.

If you have to shut down and leave equipment in locations unprotected from freezing temperature, be sure that proper drainage has burned the bridge between yourself and responsibility for damage and destruction of equipment in your care.

Missouri Valley, Iowa. FRANK BENTLEY.

Oil Engine Operation by Pyrometer

EXHAUST GAS temperature in internal combustion engines provides a valuable guide to conditions of operation, as most defects are reflected in the exhaust temperature. A pyrometer installation can easily be arranged in the average oil engine plant, a pyrometer terminal being located in the exhaust pipe from each cylinder before the gas enters the exhaust manifold. This enables the temperatures from the different cylinders to be compared. These temperatures should be within a few degrees of each other. Any great difference in temperature will indicate that some defect exists.

Provided each cylinder is in good condition, identical exhaust temperatures indicate equal loads on all

cylinders. This is of great assistance in balancing the load, as unequal loads on the various cylinders lead to unbalanced action which may cause destructive vibration. Particularly with airless injection engines, the performance of the cylinders is greatly affected by such factors as leakage of fuel around the fuel pump plunger and fuel needle and at various parts of the valve gear.

Exhaust temperature indication provides the most reliable guide to a knowledge of the cylinder output and, if the attendant knows what the exhaust temperature should be at different loads and has the necessary experience to interpret the readings, he should find it easier to obtain efficient operation through a knowledge of the exhaust temperature than by taking indicator cards of an engine since, although performance of the cylinder is indicated in the latter case, this method is open to errors unless carried out by an experienced engineer.

In addition to showing the temperature, a chart which will give a daily record of the exhaust temperatures can be arranged. The average exhaust temperature on a four-cycle engine is about 750 deg. F., the exact temperature being dependent on the load and design of the cylinder. In one installation, a four-cylinder engine was fitted with pyrometers indicating the following exhaust temperatures: No. 1 cylinder, 750 deg. F., No. 2, 755 deg. F., No. 3, 750 deg. F. and No. 4, 850 deg. F. An examination of No. 4 cylinder revealed a badly pitted exhaust valve just on the point of burning out. When this was rectified, a temperature of 750 deg. F. was shown also.

Good combustion is indicated by normal temperatures on all cylinders and by a clear exhaust. When the exhaust is dirty, one of the exhaust temperatures will usually be found to be slightly high and the fuel supply to this cylinder should be cut down until the temperature is brought to normal. If the exhaust still continues to be dirty, the fuel supply to the other cylinders should be adjusted until the temperature begins to drop. After-burning and leaky fuel valves cause a variation in the exhaust temperature and, when the engine will not carry full load without creating excessive exhaust temperatures, an overhaul is advisable.

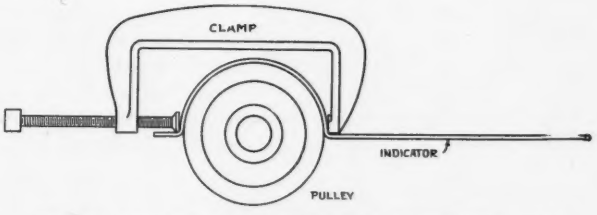
In two-cycle engines, the exhaust temperatures are lower, ranging from 600 to 650 deg. F., due to some of the scavenging air being carried away with the exhaust gases. As these engines have no exhaust valves, the indications are slightly different but the temperature indicates the efficiency of the scavenging. This is greatly affected by the formation of carbon deposits on the exhaust ports, piston heads and baffling arrangements. An increased temperature points to insufficient scavenging air entering the cylinders, while a decreased temperature points to more or less scavenging air being carried away, for some reason, with the exhaust gases.

Experience with exhaust gas pyrometry is, of course, necessary. The temperatures attained with the engine in first class condition must be known. With this as a basis, I have found pyrometer readings to be a good guide in detecting trouble and, better still, in indicating trouble before it becomes serious. It is inadvisable for engineers to attempt to attain identical temperatures on all cylinders; a difference of say 10 deg. F. is allowable and does not necessarily indicate that there is anything wrong with the engine.

Brentford, England. W. E. WARNER.

Pulley Alinement Indicator

HEREWITH IS A suggestion for an indicator which can be clamped around the pulley rather than on the end of the pulley as shown by Mr. Leopold on page 1109 of the October 15 issue. If the indicator is clamped on the pulley end, it is liable to interfere with the chalk line. Often the rim edges of both pulleys must be in the same straight line when properly alined, and



CLAMP SERVES AS CONVENIENT FASTENING FOR INDICATOR ROD

then the method suggested by Mr. Leopold would be less satisfactory than the method indicated in the sketch.

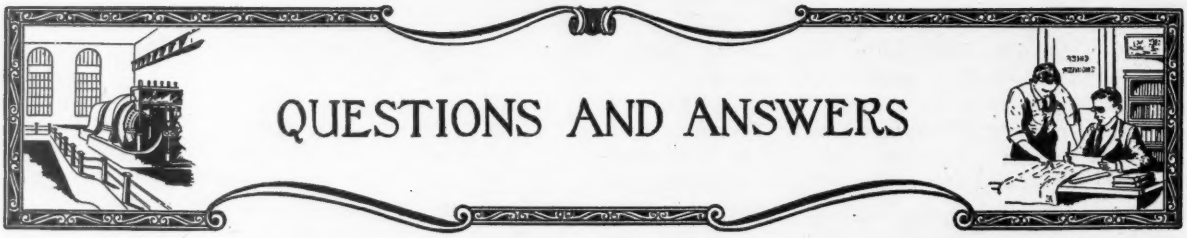
As Mr. Leopold states, the longer the indicator rod the better but, of course, it must not be so long that the end will strike the floor or wall when the pulley is rotated. That, as I see it, is the only limitation to the length of the indicator.

Mr. Leopold's suggestion to set the pulley at a slight advance of alinement so as to allow for slack and for deflection of the shaft due to belt pull is good. In fact, the same allowance should be made for both pulleys although, of course, the shaft of smaller diameter will deflect more than one of large diameter.

I realize that, for large pulleys, a clamp of the type here shown is impossible because clamps don't come in such large sizes. There are, however, many ways in which a wire can be fastened around a pulley, all of which are preferable to fastening at the end.

Newark, N. J. W. F. SCHAPHORST.

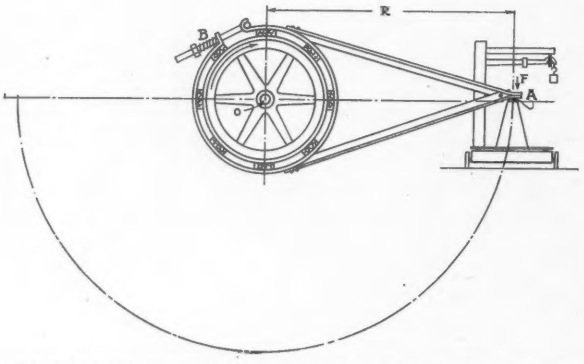
ST. JOHN RIVER POWER CO., a subsidiary of the International Paper Co., New York, has completed the construction of a new hydroelectric power plant on the St. John River, with initial output of 60,000 hp. divided among three units, each of 20,000 hp., at Grand Falls, N. B., said to be the largest generating plant of its kind in the Maritime Provinces. The plant site is about 225 mi. north of St. John, where large tract of land has been acquired. The parent company will use the majority of output for the operation of its newsprint mill at Dalhousie, Quebec, now in course of construction and reported to cost more than $1,200,000. At the same time, power will be furnished under contract to the Frazer Companies, Ltd., totaling about 20,000 hp. for the operation of pulp and paper mills of the company in this part of the country. At a later date, it is proposed to increase the capacity by 20,000 hp., making a rating for the plant of 80,000 hp. The new station is operating under a water head of 132 ft.



Brake Horsepower Calculation

CAN YOU LET ME know a simple formula for determining the brake horsepower of a small engine or electric motor? V. M.

A. The simplest possible method of determining the brake horsepower of an engine is by use of a prony brake such as illustrated. The formula used is F × 3.1416 × 2 × R × N ÷ 33,000 = HP where F = net force acting downward on the scales = pressure on the scales minus the weight of the arm and block.



PRONY BRAKE SERVES AS SIMPLE METHOD FOR DETERMINING BRAKE HORSEPOWER

3.1416 = the relation between the circumference and diameter of a circle.

R = horizontal length of arm of the brake in feet.

N = number of rotations of the flywheel per min.

Total foot pounds of work developed per minute is the product of the net force acting on the scales and the distance through which it acts per minute.

Then 3.1416 × 2 R multiplied by N will give us the distance the force F acts in one minute and the brake horsepower would be obtained by dividing by 33,000.

In using the type of prony brake illustrated, the weight of the arm on the scale is obtained by opening the screw B until the blocks are loose on the flywheel. The rim of the flywheel is then lubricated and turned very slowly in the direction of running while the pressure on the arm is registered on the scale. This weight of the arm and block deducted from the pressure exerted on the scale while the engine is under test gives the net force, F.

Care must be taken to measure the arm R, which is equal to OA, in a horizontal direction since the force acts vertically downward and the force and arm must be at right angles.

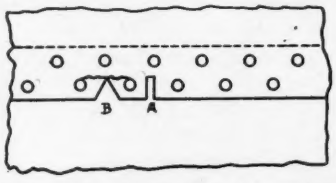
For small engines, two parallel ropes fitted with wooden blocks and wrapped around the flange of a pulley serve well as a prony brake. In this case two spring balances are used, one attached to the rope and fastened to the upper part of a standard that may be placed alongside of the face of the pulley and the other to the lower part of this standard. The net force acting in this case is the difference of the forces registered on the two spring balances. The arm of the brake is the distance from the flywheel center to the center of the rope, measured in feet.

If, during a test of an engine running 250 r.p.m., the length of the brake arm R is 5 ft. and the net pressure on the scale is 120 lb. the horsepower developed on the brake will be Br.hp. = F × 3.1416 × 2 × R × N ÷ 33,000 = 120 × 3.1416 × 2 × 5 × 250 ÷ 33,000 = 28.6 hp.

Boiler Seam Defects Inspected by Slotting

YOUR ANSWERS to the following questions will be appreciated:

1. Assuming in all cases that the water glass is correctly located with reference to the lowest permissible water level for the type of boiler and that, in the course of regular operation, the water has dropped out of sight in the glass (due to closed feed valve, stopping of pump, or similar condition) is it safe practice to turn on the feed or to start to feed water into the boiler without checking the fire, provided that the water can be made to bob up in the glass by manipulating the drain valve on the glass?



GROOVE CUT BY CAPE CHISEL DISCLOSES FRACTURE IN BOILER PLATE

2. What is the process of slotting a boiler plate to determine whether defects exist in the seam? How is it done and how is the plate repaired after slotting? A. G. H.

A. If water came from the drain cock when opened it would indicate that the water level was not below the crown sheet or danger zone and in this case checking the fire before feeding water into the boiler would be unnecessary but, if no water drips from the drain cock when it is opened, no water should be fed into the boiler until the fire has been sufficiently checked. If there is any doubt regarding the height of the water in the boiler, it is best to check your fire before feeding.

2. Defects at the edge of a lap-riveted joint in a boiler are determined by chipping into the outer sheet

of the joint from the edge, as shown at A in the illustration, until you have passed the place at which fracture is thought to be. After slotting, the plate is chipped away in V-shape as shown at B and the edges are calked, or in some cases welded.

Safe Working Pressure for Drum

WHAT IS THE safe working pressure for a steam drum 7 ft. in diameter having dished heads, one $\frac{9}{16}$ in. thick and the other $\frac{3}{8}$ in. thick? The holes for the rivets are 1 in. in diameter, the pitch is $2\frac{7}{8}$ in., thickness of shell, $\frac{5}{8}$ in. The joints are double riveted. The tensile strength of the plate is 65,000 lb. per sq. in., the shearing strength of rivets 38,000 lb. per sq. in. and the factor of safety to be used is 5. J. B.

A. The values of the factors in the following equations are:

p = pitch of rivets in inches on the row having the greatest pitch = 2.875 in.

t = thickness of plate in inches = 0.625 in.

TS = tensile strength in pounds per square inch = 65,000 lb.

d = diameter of the rivet after driving or diameter of rivet hole = 1 in.

n = number of rivets in single shear per unit length of joint which for a double riveted joint = 2

s = shearing strength of rivets = 38,000 lb. per sq. in.

a = cross sectional area of the rivet after driving = 0.7854 sq. in.

c = crushing strength of mild steel which is taken as 95,000 lb. per sq. in.

The bursting strengths of the various elements of the drum are:

Strength of solid plate
$= p \times t \times TS$
$= 2.875 \times 0.625 \times 65{,}000$
$= 116{,}800$ lb.

Strength of plate between rivet holes
$= (p - d)\ t \times TS$
$= (2.875 - 1)\ 0.625 \times 65{,}000$
$= 76{,}150$ lb.

Shearing strength of rivets
$= n \times s \times a$
$= 2 \times 38{,}000 \times 0.7854$
$= 59{,}800$ lb.

Crushing strength of plate in front of rivets
$= n \times d \times t \times c$
$= 2 \times 1 \times 0.625 \times 95{,}000$
$= 118{,}800$ lb.

Shear of rivets is, therefore, the weakest point of the seam. The joint efficiency is $59{,}800 \div 116{,}800 = 0.512$ or 51.2 per cent.

Allowable working pressure on the drum, considering solid shell plate $= TS \times t \div (R \times FS)$.

where R = radius of shell in inches = 42
FS = factor of safety = 5

Allowable working pressure on solid shell will then be $65{,}000 \times 0.625 \div (42 \times 5) = 193.5$ lb. per sq. in.

Allowable working pressure on actual shell = $193.5 \times 0.512 = 100$ lb. per sq. in.

For concaved bumped heads, the safe working pressure is $P = 0.6\ (t - \frac{1}{8})\ 2\ TS \div (R \times F)$.

where t = thickness of head in inches = 0.375 in.
TS = tensile strength of metal = 65,000 lb.
R = radius to which head is dished. Since R was not given, it is assumed to be 72 in. This radius should be at least 80 per cent of the shell diameter.
F = factor of safety recommended by A. S. M. E. code = 5.5

Then, $P = 0.6\ (0.375 - 0.125)\ 2 \times 65{,}000 \div (72 \times 5.5) = 49.3$ lb. per sq. in.

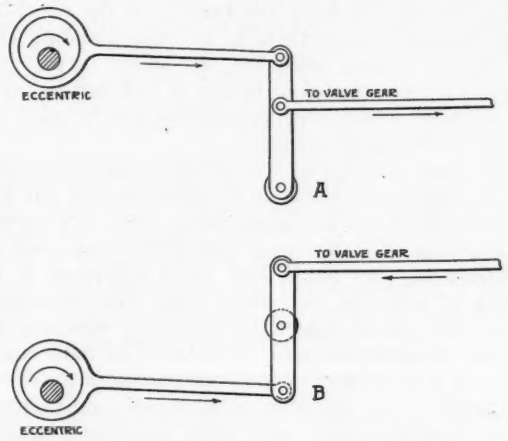
From the foregoing calculations, the weakest element is found to be the thinner dished head which will stand a pressure of only 49.3 lb. per sq. in.

Valve Gear Action and Setting

HOW SHOULD the valve of an engine having an inverse rocker arm be set? J. B.

A. By inverse rocker arm, we take it that a rocker arm in which the fulcrum pin lies between the ends at which the eccentric and valve rods are attached as shown at B in the sketch, is meant.

In this case, it will be seen that for a given movement of the eccentric the valve rod of B would move



INVERTING OF ROCKER ARM CAUSES THE VALVE TO MOVE IN THE OPPOSITE DIRECTION

in a direction directly opposite to that of A. In setting the valve, therefore, you should proceed in the regular way but take into account the reversal of movement of the valve rod and change your directions accordingly.

Cable Installation in Conduits

BY WHAT METHODS is heavy, long, electric transmission wire pulled through underground conduit? I. W. O.

A. Two methods are used of starting a line through a conduit; one starts with a ferret or mouse to which is attached a silk thread. Larger and larger line is pulled through in succession after the ferret is caught at the far end of the conduit and, finally, the cable itself is pulled through by use of a winch, preferably power driven, as when a truck supplied with a power winch is employed.

The other method of starting the line is by the use of a stiff wire or steel tape which is provided with a rounded end. This is pushed through the conduit, the rounded end preventing it from catching at joints. Electric companies use this method successfully for city block lengths.

EDITORIAL COMMENT

An Engineer as President

Now that the voters of the country have decisively settled the question as to the man to head our government for the next four years, the success of the coming administration will depend to a large degree upon the confidence which the people have in the ability of Mr. Hoover to administer the affairs of his office, to propose and secure the enactment of legislation, to foster favorable foreign policies and domestic developments. Confidence is a psychological condition and may be justified or unfounded according to the facts but present conditions and past experience justify confidence in Mr. Hoover. To know the facts is, in the viewpoint of an engineer, prerequisite to an understanding of a problem and, being engineers, we should expect Mr. Hoover's administration to be one of fact finding, upon the results of which recommendations will be made according to the needs indicated.

Not since the days of George Washington has there been an engineer at the administrative head of our government and it will be interesting to note in what way the handling of government will differ from past administrations. We might look for a difference in the manner of selecting the cabinet and other appointive offices. We should expect the legislative bills originating with the administration to be based on indisputable facts and thus subject to less controversy in the House and Senate. An engineer recommends improvements in his client's industry only after investigations have been made which show that the expenditure is justified. Will not a president who has practiced engineering as a profession be expected to make recommendations for internal improvements in a similar manner, i. e., to base his judgment of the need on a fact-finding survey?

Although it is unlikely that many voters chose Mr. Hoover on account of his engineering experience, he does represent the engineering type of mind and the honor conferred upon him is an honor to the profession he represents.

Keeping Fit

In every man's life there comes a time when organic changes take place and individual habits of diet and exercise must be changed in order that he may keep in the running. Power plants also have their day, then suffer from deterioration and obsolescence. Just when or where diseases may attack the plant is no easier to predict than are the fortunes of a man. To recognize disease when it first puts in its appearance and to head off unnecessary operating expense by making needed repairs and improvements is one of the most valuable functions an engineer can perform for his company.

So many revolutionary changes have taken place in the art of steam and power generation during the past decade that obsolescence has crept into many plants unnoticed. Combustion equipment, boiler design, feedwater preparation, steam turbine design, electrical equipment and the entire heat cycle have undergone improvements that have greatly increased efficiencies and reduced operating costs. To take advantage of all of these radical changes would, in many cases, require the complete rebuilding of the power plant. This was the solution decided upon in the power plant of the Franklin Sugar Refining Co., the features of which are described in the leading article of this issue. The old plant, a model in its day, outlived its usefulness and its walls now house equipment representing the advanced practice of today. This is a lesson for many industrial power plant engineers to study in connection with their own plants. The art is advancing and we must avoid being caught in the rear ranks.

Clinkering of Semi-Bituminous Coals on Underfeed Stokers

Engineers do not agree that relative operating troubles from clinkering when using different coals in the same furnace can be predicted from a knowledge of the fusibility of the average ash of the coals. It is difficult to allot the blame correctly and the difficulties may be due to differences in the burning characteristics of the combustible of the coals, to the size of the coal pieces, or to the adjustment of the stoker or its operation.

A series of tests has been made by the Pittsburgh Experiment Station of the United States Bureau of Mines at the boiler plant of an industrial firm in which five semi-bituminous coals having different softening temperatures of the ash but obtained from the same mining district were burned on an underfeed stoker. Similar operating conditions were maintained throughout the investigation and similar tests were made with each coal. A summary of the results and observations shows that the quantity of clinker formed and the troubles attributable to clinker formation decreased as the softening temperature of the ash increased; that is to say, the coal having the ash of the highest fusibility gave the least trouble. It does not follow that given users would have found the same coals generally satisfactory in the same order or that the conclusions reached would be the same with other methods of burning; the investigation, however, showed that the fusibility was a measure of such operating troubles as could be directly attributed to the quality of the ash in the coal.

Due to the great number of variable conditions surrounding the problem, engineers are coming more and more to the conclusion that the only safe way to judge the value of a coal in any plant is to give it a fair trial under operating conditions in that plant. An analysis of the coal and its ash can, apparently, give little more than an indication of its fitness for a given furnace.

Fuel Handling, Storage and Preparation Number

JANUARY 1, 1929

FUEL is the chief raw material and an item of largest expense in the power plant. It is essential that it be available in sufficient quantity at all times, that it be of such quality and in such form as will best serve the needs of the plant.

To meet these requirements there must be provided adequate storage and reclaiming facilities to insure against market shortage and to take advantage of price fluctuations; also preparation methods should be such as to adapt it properly to the requirements of the furnace for economical combustion.

Detailed treatment of these subjects will be presented in the January 1, 1929 issue of Power Plant Engineering, the 21st Annual Reference and Textbook number. This number is designed to furnish designing, construction and operating engineers and officials of companies owning and operating plants in all parts of the country and in all industries with information on a subject of the highest importance to them. They are constantly seeking to bring their plants up to higher and higher standards of performance and one of the most important factors in this endeavor is the handling of fuel.

Coal and Ash Handling

Coal handling involves the unloading from cars or boats, carrying to storage or to bunkers, reclaiming from storage to bunkers and delivery from bunkers to furnaces, with such weighing or measurement as is necessary at various points.

Under coal handling, the requisites for a satisfactory system, speed, capacity, automatic action, durability, low cost for power and upkeep will be considered. Methods of unloading and handling by cranes, conveyors, scraper systems, hoists and pneumatic carriers will be treated, as will also metering and weighing.

Characteristics of various systems, bucket and belt conveyors, trough and screw systems, portable conveyors, drag scraper systems, skip hoists, larries, various types of cranes for dock, yard and plant use and pneumatic systems will be fully discussed.

In ash handling, some of the chief considerations are durability of the equipment, freedom from dust and dirt, low labor and power costs, and reliability. The entire process, from ash hopper to railroad car or dump will be considered and the features of various systems treated. The details of hoppers, gates, conveyors, hoists, pneumatic systems, hydraulic systems, storage tanks, telpher conveyors, and methods of reclaiming combustible from ash will be included in this section.

Storing and Reclaiming Fuel

Fuel storage is a matter that often receives too little consideration. It has, however, been carefully studied and the conditions for satisfactory storage are reasonably well defined.

The objects of storage will be considered in one section, covering emergency provision, seasonal prices and transportation, the effect of location on storage requirements. Following this, the problems involved in storage will be taken up, presenting full information for their solution.

Many data are available from experience as to conditions which must be maintained for satisfactory storage to avoid heating, weathering and deterioration. Requirements will be fully defined and measures necessary to detect heating and deterioration will be indicated.

Details concerning storage systems and reclaiming methods will be given, together with costs for handling and for holding in storage. Experiences of central stations and industrial plants will be drawn on for facts and figures.

Preparation of Coal

Use of run-of-mine coal with big lumps and dust mixed indiscriminately is no longer favored. Even for storage, it is recognized that fair degree of uniformity as to size is required. Preparation of coal involves removal of trash; crushing, sizing and screening for storage and for furnace use; drying and pulverizing, when needed; methods of handling prepared fuel.

What size is desirable for various coals and purposes, methods of crushing and the machinery used, systems for drying in sized and in pulverized forms, degree of fineness needed for pulverizing? All these factors have great effect on the economy of a power plant. Adequate treatment will be given to all these matters in the section devoted to this subject.

Storage and Handling of Oil

Oil fuel handling and storage will be the subject of an important section, covering car unloading, tanks for storage, pumps, pipe lines and valve systems, strainers, heating of oil pressures in the system and provision for cleaning the system.

Wood Refuse and Gas

Wood refuse requires special consideration which will include storage, preparation, transporting, safety precautions and methods of supplying fuel to the furnace. Gas as a fuel has limited application in power plants but the storage, piping systems and control of this fuel and pressures used will be given sufficient place to cover the requirements for safe and economical operation.

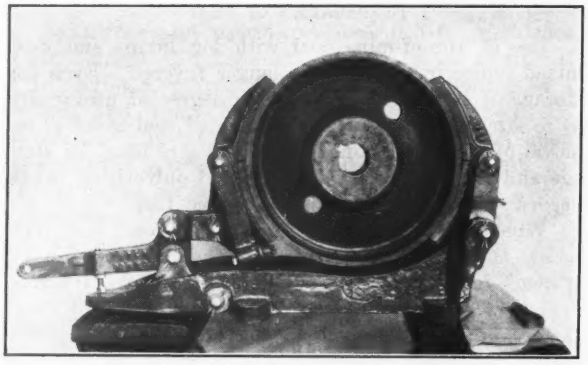
Throughout the issue prominence will be given to experience in actual plants and to methods that have proved successful and satisfactory in practice.

Fuel is vital to the power plant. It must be considered at all times and the use of proper methods of handling, storage and preparation can contribute greatly to the reliability, economy, and convenience of plant operation. The January 1, 1929, issue will be a summary of experience and good practice in these departments of plant operation and will aid engineers in the studying of the best methods of preparation, storage and handling of fuel and assist them in choosing the methods which best meet their conditions.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Brake for Bridge Drives of Cranes

ANNOUNCEMENT is made of a new brake arranged for lever operation, known as the mechanically-operated Type WB brake. Of the shoe type, it is intended for the bridge drives of electric traveling



BRAKE HAS THICK MOLDED ASBESTOS SHOES

cranes, lift bridges, electric hoists and other applications requiring foot-operated or hand-lever operated brakes.

This new brake, built by Electric Controller & Mfg. Co., Cleveland, Ohio, is a modification of its Type WB electrically-operated brake; practically all wearing parts of the new mechanically-operated brake are interchangeable with parts of the electrically-operated brake.

Tendency toward the use of anti-friction bearings on cranes and other machinery has resulted in an increased amount of work to be performed by the brake. A crane equipped with anti-friction bearings will drift along with practically undiminished speed when the controller is shut off, with the result that the brake must stop the crane unaided by bearing friction. This has necessitated improved brake design with increased wearing qualities of friction linings. The Type WB brake is equipped with unusually thick molded asbestos brake shoes, designed to require renewal only after long periods of service.

Pushing Pipe Underground

FOR PUSHING water or gas pipe, pipe for electrical service or for oil heating supply, under paved streets or alleys or under gardens or lawns, irrespective of temperature conditions, the Simplex pipe pushing jack has been developed.

The pipe is gripped by jaws in the center of the jack, as illustrated and one or two men operating each of the two levers cause the pipe to be pushed through the ground.

These jacks are built in two sizes—the No. 332 for pushing pipe of ¾ to 2 in. in diameter and the No. 334

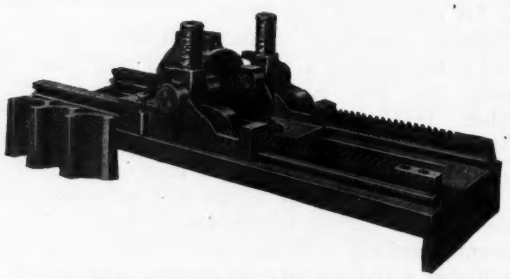


FIG. 1. JACK GRIPS PIPE THROUGH SET OF JAWS, SHOWN AT LEFT

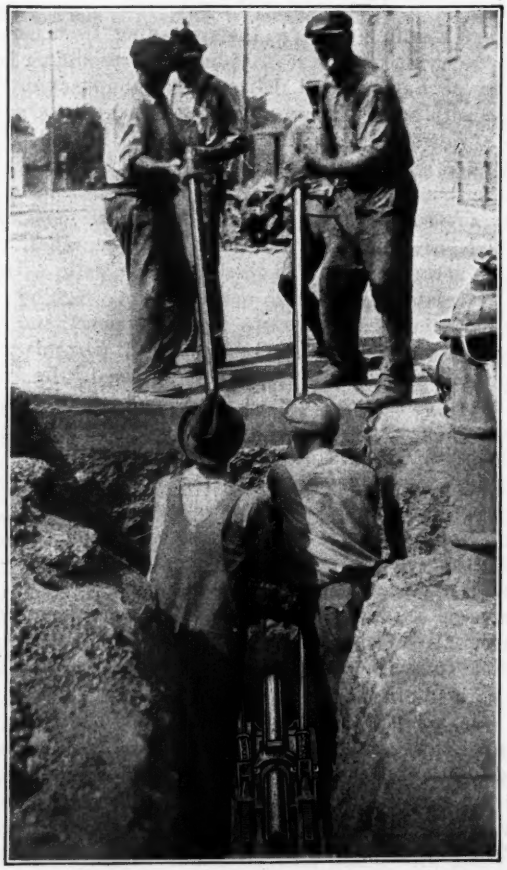


FIG. 2. JACK IN USE, PUSHING 3-IN. PIPE THROUGH SOIL UNDER CONCRETE ROAD

for pushing pipe of 2 to 4 in. in diameter. Each size of pipe requires a set of jaws to conform to the size of pipe, to avoid crushing or distorting the pipe.

Bulletins descriptive of the Simplex pipe pushing jacks or moving picture reels illustrating them in action, may be obtained from Templeton, Kenly & Co., Ltd., Chicago, Ill., manufacturer of the Simplex jacks, or from the branch offices of the Graybar Electric Co., Inc.

Van Stone and Cup Joints for Small Pipe

WHILE THERE is nothing new in the construction of the pipe joints recently developed by the National Valve & Manufacturing Co. of Pittsburgh, Pa., they are radical departures from the usual style of joint used for drips, drains, bypasses and other small-sized steam lines. The square lap Van Stone joint and the cup joint have been in use for a number of years in sizes of 2 in. and over but under 2 in. neither of these joints has heretofore been developed. The usual practice has been to use screwed or screwed and welded connections, both of which were being used when the average steam plant operated at 125 lb. pressure.

The Van Stone joint as shown in Fig. 1 is ½ in. in size and is designed to withstand any present-day operating pressure and temperature. The lap has a thickness equal to that of the tubing from which it is formed even after facing front and back. This back facing is intended to insure perfect alinement. The radius of the flange and that of the laps are concentric to afford proper bearing of the flange.

Both this joint and the cup welded joint shown in

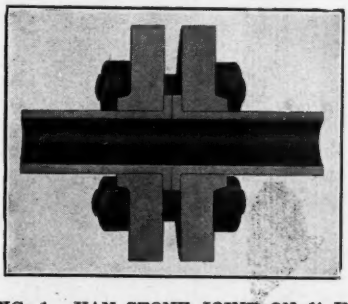


FIG. 1. VAN STONE JOINT ON ½-IN. PIPE

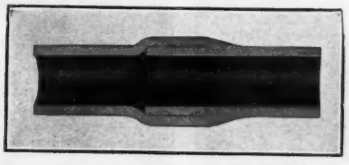


FIG. 2. CUP WELDED JOINT FOR PIPE UNDER 2 IN.

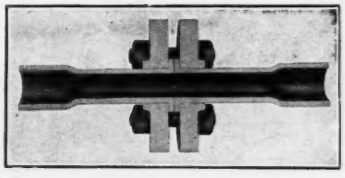


FIG. 3. METHOD OF INSTALLATION

Fig. 2, according to tests recently made, show an average ultimate tensile strength of 60,000 lb. per sq. in. Figure 3 shows one method of installation. Sections can be furnished as short as 9 in. from face of lap to face of cupped end.

Westinghouse Develops New Insulators

AN ENGINEERING development in insulators of great importance to the central station industry has been announced by the Westinghouse Electric and Manufacturing Co.

This development consists in the application of a metallic glaze to the line and tie wire grooves which is designed to reduce interference in radio reception from the insulators.

In the ordinary insulator with the usual ceramic glaze, there is a high resistance contact between the conductor and the porcelain. The flow of charging current under this condition consists of numerous arcs; while in all ordinary cases this will cause no radio interference, yet in exceptional cases it may. The

WESTINGHOUSE INSULATOR WITH METALLIC GLAZE

metallic glaze, furnishing good contact between the conductor and the porcelain because of the intimate connection between the glaze and the porcelain, removes even this remote chance for trouble.

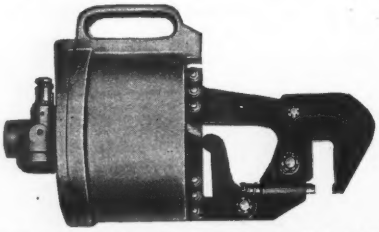
Tests to determine the measure of improvement of the metallic glaze insulator over the ordinary insulator, showed that when the interference was intense at 25 kv. with the latter insulator, it was scarcely noticeable at 90 kv. in the metallic glaze insulator.

It is believed that the metallic glaze insulator will assist considerably in the solution of problems of interference now confronting the central station industry in congested districts.

Portable Pneumatic Riveter for Light Work

MANUFACTURERS of light sheet-metal products will be interested in a new portable pneumatic riveter designed to squeeze instead of hammer light rivets into place. This machine, known as the CP squeeze riveter, has been brought out by the Chicago Pneumatic Tool Co., 6 East 44th St., New York. The squeeze riveter is made in two sizes, the smaller one weighing but 8 lb. and designed for driving steel rivets up to ⅛ in. diameter, duralumin rivets up to $\frac{5}{32}$ in. diameter and aluminum rivets up to $\frac{3}{16}$ in. diameter. The larger size weighs

16½ lb. and is for steel rivets up to $\frac{3}{16}$ in. diameter, duralumin rivets up to $\frac{5}{16}$ in. diameter and aluminum rivets up to ⅜ in. diameter. The yoke is made to be easily and quickly removed and a wide range of inter-



SQUEEZE RIVETER FOR STEEL, DURALUMIN AND ALUMINUM RIVETS

changeable yokes can be furnished for almost any size of gap and reach. Anyone interested in driving light rivets will be mailed S.P. 1674, illustrating and describing the squeeze riveters, upon application to the manufacturer.

Duke Power Co. Constructs River Bend Station

ANNOUNCEMENT IS MADE by the Duke Power Co., Charlotte, N. C., that by Sept. 1, 1929, it expects to have its new River Bend Steam Station in operation near Mt. Holly, N. C., on the Catawba River.

RECENT VIEW OF CONSTRUCTION ACTIVITIES ON SITE OF RIVER BEND STEAM STATION, NEAR MT. HOLLY, N. C.

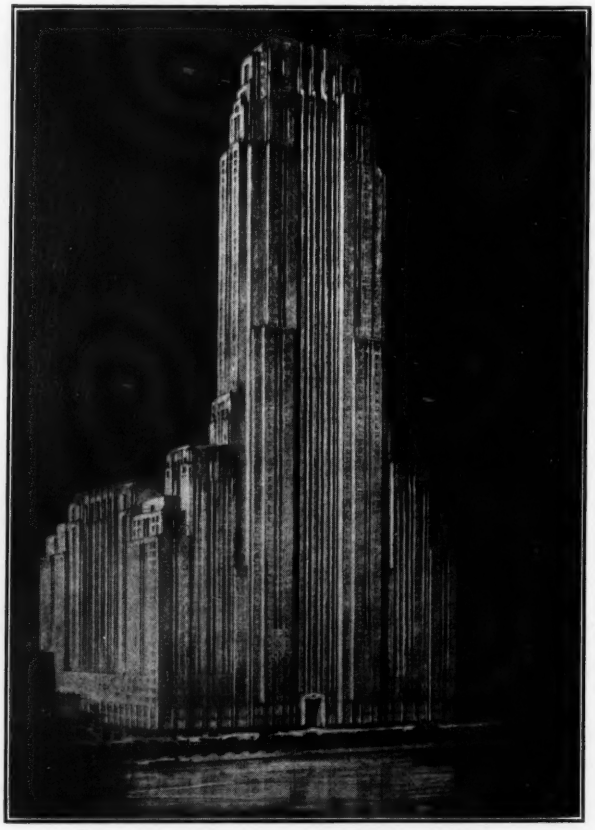
As shown, construction work is under way on the initial installation which will consist of two 55,000-kw. steam turbine generating units, giving a total capacity of 110,000 kw. The site is suitable for expansion of the plant to a capacity of 800,000 kw., in case the future conditions of load and system operation should justify such growth.

River Bend Steam Station will be designed to operate normally on a 24-hr. per day basis. On the Duke Power Company's system, the steam plants always operate in this way; either they go on the line 24 hr. a day at full load and designed economy to make a specified amount of power for the system or else they are shut down completely.

For the new plant, turbines will be Westinghouse, 55,000-kw., single-cylinder machines using steam at 450 lb. throttle pressure, designed for extraction feed-water heating. Each unit is to be served by a C. H. Wheeler condenser and Elliott Co. extraction heaters. Evaporators and deaerators will be installed but aside from these, there will be no other treatment of the feedwater. Steam will be supplied to the turbines by Babcock & Wilcox boilers fired with pulverized coal by a Fuller Lehigh unit mill system.

Chicago Apparel Mart to Install Power Plant

MODERN SKYSCRAPERS are approaching such magnitude as to require power plants greater than those in many medium size factories, according to a study which has been made for Walter W. Ahlschlager, architect and designer of the Chicago Apparel



Mart, which is expected to be the tallest and largest building in the world.

"Study of power requirements for the Chicago Apparel Mart shows that a power plant within the building will be absolutely necessary to take care of the heavy electric load for both lighting and power," Mr. Ahlschlager said. "A rough estimate shows a total connected light load of 5300 kw. and a total connected power load of approximately 9400 hp.

"Our plans, therefore, call for a battery of boilers capable of developing 20,000 hp., with an approximate coal consumption of 225 t. a day. These boilers will furnish either directly or indirectly power, light, heat,

refrigeration and ventilation for the entire structure, which will have a gross floor area of 5,097,778 sq. ft.

"This building is in no sense a factory, yet its requirements for power will be far in excess of the requirements for an average factory building. The building will have space for restricted light manufacturing but most of the space will be used for sales, exhibition and office purposes. The heavy load of light and power required is principally for the operation of the building and the furnishing of the necessary light, heat and ventilation for a normal day-time population of 18,000 people."

Study of the power plant for the new skyscraper has shown some interesting facts, according to the architect, concerning the relative power consumption as between factory wage-earners and office wage-earners. The 1925 Census of Manufacturers showed the average factory to be utilizing 4 hp. for every wage-earner employed. These were principally employes working on power driven machines or using power in their work. The 18,000 persons, populating the Chicago Apparel Mart, will be principally wage-earners but they will be office workers, yet the skyscraper in which they work will have to produce 1.1 hp. for every person in it. This power will not be used to drive machinery but to supply the comforts of an efficient office building.

Daily coal consumption in the Chicago Apparel Mart will average 225 t., yet the mechanical arrangements for stoking are such that probably not more than five men will be employed in operating the boilers. Coal will be bunkered below the track level to concrete bins directly over the stoker hoppers with a weighing larry for conveying the coal from the bunkers into the hoppers. A continuous-bucket coal conveyor will be arranged to convey coal from the reserve storage bunkers to the gravity feed bunkers above the boilers; this same conveyor is designed so that it can remove ash from the ash bunkers below the boiler room to an ash bunker above the tracks, whence the ash can be dumped directly to cars on the tracks. The power plant will have the tallest smoke-stack in the world. This stack will occupy a space of 20 sq. ft running through the entire 75 stories of the structure.

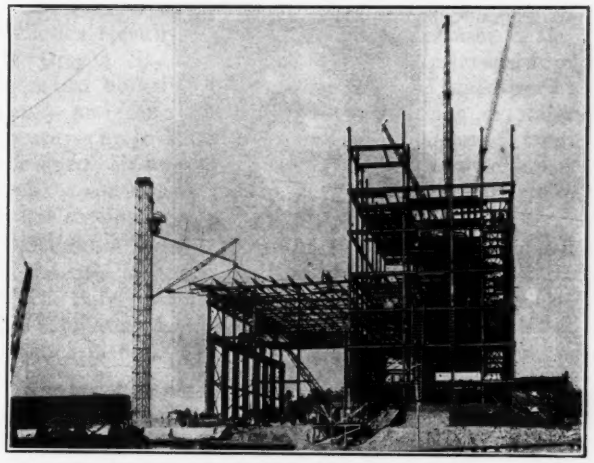
Operation of this skyscraper power plant will be under the administration of the C. F. Noyes National Realty Corp.

Alabama Power Co. Builds New Gorgas Plant

CONSTRUCTION WORK is going forward rapidly on the new steam station of the Alabama Power Co., known as Gorgas Steam Plant No. 2, adjacent to the existing Gorgas steam station, near Birmingham, Ala. The new plant is designed for an ultimate installation of four 60,000-kw. generating units; the initial installation consists of one 60,000-kw. unit. This initial installation is designed to use 400-lb. pressure at the turbine throttle, a steam temperature of 725 deg. F. and to have a net plant economy for a year's output of approximately 16,000 B.t.u. per kw-hr. On account of high temperatures of circulating water at Gorgas, this unit was designed for best efficiency with 2-in. back pressure at the exhaust nozzle.

As described in a recent A. I. E. E. paper by A. T. Hutchins, superintendent of production, Alabama Power Co., in this unit the generator is a 60,000-kw., 90 per cent power factor, 13,800-v., single-shaft, 1800-r.p.m. machine, with a closed generator cooling system using raw water for cooling. The turbine is a three-valve, 17-stage machine with 4 bleed points for heating the feedwater to 360 deg. F. at 52,000-kw. load and a B.t.u. rate chargeable to the turbine of 11,350 B.t.u. per kw-hr. at that load. The unit is built for a maximum load of 66,667 kw. at unity power factor.

Steam will be supplied to this turbine from two boilers, each rated at 3040 hp. and equipped with pulverized fuel burners and fans of sufficient capacity to secure a maximum rating of 450,000 lb. of steam per hour. With each boiler there is installed a plate type air preheater of 30,600 sq. ft. Furnaces have fin tube side and rear walls with 3050 sq. ft. of surface each. Each boiler is equipped with eight cylindrical burners



GORGAS STEAM PLANT NO. 2 UNDER CONSTRUCTION

for horizontal firing and has a furnace with cubical contents of 24,000 cu. ft. so that there will be a release of 18,000 B.t.u. per cu. ft. per hr. at normal rating, this being approximately 350,000 lb. of steam per boiler per hr. and the specified efficiency of boiler unit and furnace at that output is 83.7 per cent.

These boilers will be supplied with pulverized coal through a central system from three 15-t. mills having 6 rolls each. These are arranged for mill drying and the air exhaust from the system, with the fines not thrown down in the cyclones, goes directly to the furnace. This is intended to provide a system as free from escaping dust as is possible to secure. In fact, a great deal of attention to design is given to securing freedom from dust in all parts of the plant.

It may be interesting to note the reason for some of these features of design. The unit arrangement is followed without spares, capacity at the hydro plants being available in case of a drop in load on any steam plant unit. The use of 400-lb. pressure at the throttle results in maximum drum pressure of 475 lb. gage and this necessitated the use of 600-lb. valves and fittings. It was found that the increased capacity of the turbine and slight increase in efficiency more than compensated for the added cost of valves and fittings designed for 600-lb. pressure over those for 400-lb. pressure.

Use of air preheaters and a correspondingly high temperature of gases leaving the boiler surface, together with the high pressure used, showed good economy in the use of the fourth bleed point for feedwater heating. On account of crowding of piping and heaters, however, and the consequent difficulty in operation and maintenance, it is likely that the next unit will use only three bleed points for feedwater heating.

Death of Frederick Kent Copeland

FREDERICK KENT COPELAND, president of the Sullivan Machinery Co., since 1892, died at Claremont, N. H., on November 10. He was on a visit to the company's eastern works at Claremont, when he was taken ill. It became necessary to operate for appendicitis, death resulting two days later.

Mr. Copeland was born in Lexington, Mass., and was graduated from Massachusetts Institute of Technology

in 1876. After several years spent in Iowa and Colorado in mining engineering work, he helped organize the Diamond Prospecting Co. in 1884 and later became its president. This company engaged in contracting with the diamond core drills made at Claremont, N. H., by the Sullivan Machine Co.

In 1892, the two companies were merged as the Sullivan Machinery Co., with Mr. Copeland as president.

Mr. Copeland maintained active leadership up to the date of his final illness. He was a member of numerous engineering societies, including the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the New York Engineers' Club and of the Bankers' Club of New York and was a past president of the Engineers' Club of Chicago, of the Western Society of Engineers and of the National Metal Trades' Association. He had served as a trustee of Massachusetts Institute of Technology and in earlier years, as a member of the village board of Winnetka, Ill., where he made his home for nearly 40 yr.

W. B. FOSHAY Co., Minneapolis, Minn., has purchased the Mount Spokane Power Co., operated for several years as a family business by Mark F. Mendenhall, attorney of Deer Park, Washington. The newly acquired property serves Deer Park and 18 other towns in Spokane county and they will be operated as part of the Public Utilities Consolidated Corp. which is the utilities operating company for the Foshay organization.

News Notes

HAROLD C. OSMAN, secretary of the Nugent Steel Castings Co., Chicago, Ill., heretofore in charge of sales for that company, has been appointed works manager.

CRAMP-MORRIS INDUSTRIALS, INC., Philadelphia, Pa., announces that two of its subsidiaries, I. P. Morris Corp. of Philadelphia, Pa., and De La Vergne Machine Co., formerly of New York City, have consolidated their operations in Philadelphia under the name of I. P. Morris and De La Vergne, Inc.

KENNEDY-VAN SAUN MFG. & ENG. CORP., New York City, has formed and established the Kennedy-Van Saun Co. of Illinois, with an office in the State Bank Building, 120 So. La Salle St., Chicago, Ill., under the direction of T. J. Shearer.

EDWARD VALVE & MANUFACTURING CO., East Chicago, Ind., announces the appointment of James A. Riordan Co., Inc., 451 Colman Bldg., Seattle, Wash., as northwest representative, serving Washington, Oregon, Northern Idaho, British Columbia and Alberta.

CYCLONE GRATE BAR CO., Buffalo, New York, announces that it has purchased all the stock of Betson-Jewell, Inc., and that the office of the latter has been moved from Rome, New York to 9 Grimes Street, Buffalo, New York. The officers of Betson-Jewell, Inc., are John H. Vought, president; George R. Duryea, vice-president. The business will be continued under the name of Betson-Jewell, Inc.

U. DE B. DALY, president of the company heretofore known as the Roxana Petroleum Corp., has announced that his board of directors has today approved a change in the corporate name to Shell Petroleum Corp. The name Roxana has been in use since the organization of the company in 1917. Since 1923, when the marketing of Shell gasoline, Shell motor oil and other petroleum products under the Shell trade-mark was inaugurated, the name Shell has become so popular and so closely identified with the corporation itself that the name Roxana has gradually lost its significance, hence the change in the firm style to correspond with the trade name of its products has been made.

PUGET SOUND POWER & LIGHT CO., Seattle, Wash., will proceed with the installation of the first unit of its new steam power plant at Renton, Washington, to be equipped with an initial capacity of 35,000 kw. At a later date, the plant will be increased to about 200,000 kw. at a total cost of about $20,000,000.

ON OCTOBER 30 a ground-breaking ceremony for the new 60,000-kw. steam power plant of the Duquesne Light Co. at Pittsburgh was held. The new station is to be known as the James H. Reed Power Station. It is named for the late Judge James H. Reed, who organized the public utilities of Pittsburgh, which are today grouped under the Philadelphia Co., and served for 20 yr. as president of the corporation. The station will be located adjacent to the Duquesne Light Co.'s switch house and near the present power station on Brunot Island. As noted in the October 15 issue of Power Plant Engineering, the power house building will be large enough to house two 60,000-kw. turbine generators

and six boilers but at present only one 60,000-kw. unit and three boilers will be installed.

According to H. W. Fuller, vice-president in charge of engineering and construction of Byllesby Engineering & Management Corporation, plans for the station have progressed to the point where actual construction work is expected to start in December.

NUMBER 4 TURBINE-GENERATOR of the Toronto Plant of the Ohio River Edison Co. operated by the Pennsylvania-Ohio Power & Light Co. has just been placed in operation. This unit adds 37,500 kva. to the plant capacity, making a total of 150,000 kva. or 175,000 hp. This is just one-half the planned ultimate development. The generating unit is complete in every detail, but the additional boiler installation will not be completed before the end of this year. This station has been designed and constructed by Stevens & Wood, Inc., New York and Youngstown and has cost to date with all facilities about $16,000,000.

C. & G. COOPER CO., Mt. Vernon, Ohio, has purchased the manufacturing end of the Hope Engineering Co., of the same city, including the Hope manufacturing plant, plant site and engine designs. Starting with October first the Hope plant is being operated as a division of the Cooper organization. For a time, at least, the Hope organization, including its branch offices, will continue to sell and service Hope engines and other Hope equipment. This, however, is purely a sales connection and represents the only connection between the two organizations, which will continue to maintain as always their separate and unallied identities. The sale of the manufacturing end of the business is intended to permit the Hope Engineering Co. to devote more of its efforts to the pipe line and construction end of its business.

CHICAGO AUTOMATIC CONVEYOR CO., 1845 So. 55th Ave., Cicero, Ill., has recently placed on the market a new belt conveyor idler. In this device, the pulleys are made of heavy steel tubing with steel heads electrically welded flush with the ends to eliminate dust pockets. These pulleys are spaced ¼ in. apart to avoid belt creasing. Ball bearings in unit mountings are employed to preserve alinement. The mounting is intended to hold sufficient grease for 3 to 6 months' operation and quadruple labyrinth grease seal is used to protect the bearings from dust and to keep the grease from being thrown on the belt. Heavy cast-iron brackets are used which can be mounted of wood or channel brass. Three places are provided for lubricating each idler and these are fitted with alemite fittings or other types of high-pressure fittings to meet the needs of each plant.

ANNOUNCEMENT has recently been made by the American Enka Corp., 114 E. 32nd St., New York City, that Lockwood Green & Co. has been selected as consulting engineer for the building of its new rayon plant, just outside Asheville, N. C. H. K. Ferguson Co., Cleveland, Ohio, has been selected as building engineer and contractor. Work has actually begun in grading and clearing away the site for the new plant, which is on Hominy Creek, about 2½ mi. from the Asheville city limits. Here a large tract of land has been purchased and the company states that the entire project to be built will cost approximately $10,000,000. The chief construction engineer for the American Enka Corp. is Dr. A. J. L. Moritz.

Catalog Notes

IMPROVED Cochrane V-notch recording meter is described in detail in bulletin No. 679, issued by Cochrane Corporation, 17th St. and Allegheny Ave., Philadelphia, Pa. The bulletin discusses the principles of the recorder and integrator and shows by photographs and diagrams its various applications. The company is also issuing bulletin 678, entitled "Obtaining Zero Hardness in Softening Water." In bulletin 680, an extensive discussion is given of the subject of flow meters and their uses. This illustrates and describes many details of the Cochrane flow meter and contains much information on the general uses of meters. Deaerating heaters are described by the Cochrane Corp. in bulletin 681, a 44-page bulletin copiously illustrated and containing many interesting engineering data, flow diagrams and test results. The Cochrane discharger, a large capacity steam trap for high pressures is described in bulletin 682.

NICHOLSON specialties are described in a group of bulletins recently sent out by W. H. Nicholson & Co., 12 Oregon St., Wilkes-Barre, Pa. These consist of loose-leaf bulletins contained in a binder and describe three- and four-way valves for air, steam or water pressures up to 500 lb., Nicholson weight operated traps for steam, air and gas, Nicholson piston operated supertrap, expansion steam traps, flexible couplings and automatic eliminators.

BURNING WOOD REFUSE for Fuel, by J. H. Hinman, is the title of an article presented in No. 18, Vol. II of The Safety Valve, published by the Heine Boiler Co., 200 Madison Ave., New York, discussing the latest practice in boiler settings for this purpose.

IN ITS "1928 Bulletin Catalog of 20th Century Steam Appliances," Atwood & Morrill Co., Salem, Mass., illustrates and describes various types of pressure regulators, damper regulators, steam traps, back pressure valves, strainers and pump governors.

NEW SERIES of Farrel-Sykes, roller-bearing-type speed reducers from one horsepower to 5000 hp. are described in a recent illustrated bulletin by Farrel-Birmingham, Co., 344 Vulcan St., Buffalo, N. Y.

JONES TRUE BLUE PULLEYS are described and illustrated in a 24-page booklet, Catalog No. 37, issued by W. A. Jones Foundry and Machine Co., 4401 W. Roosevelt Road, Chicago, Ill. Semi-steel pulleys of both solid and split design are described as well as flanged pulleys, with complete dimensions and price lists.

EXHAUST FANS for ventilation of offices, theatres, restaurants, and so on, as well as for domestic applications, are described in a recent folder sent out by the Peerless Electric Co. of Warren, Ohio.

PORTABLE ELECTRIC hoists in single and double drum types as made by the Sullivan Machinery Co., 122 S. Michigan Ave., Chicago, are described and illustrated in Bulletin 76-J issued by the company. The driving motors are in 10 to 35-hp. sizes. The double drum is especially adapted for drag scraper work in mines, sand pits, coal-storage yards and the like. The single drum hoist is for lifting, car-pulling, hauling and one way scraper work. Ease of setting up and removal, low power consumption and ready adaptability to conditions are characteristics of these hoists.

Power Plant Construction News

Ala., Mobile—The Alabama Power Co., Birmingham, is said to be planning construction of steam-operated electric generating plant on the Hog Bayou, near Mobile, primarily for service at the new mill of the International Paper Co., New York, now in course of construction at that place. It is reported to cost more than $250,000.

Calif., Los Angeles—The Continental Can Co., 1 Pershing Square, New York, plans installation of power equipment in a new two-story plant at Los Angeles, reported to cost more than $200,000. Francisco & Jacobus, 511 Fifth Avenue, New York, are architects and engineers.

Colo., Colorado Springs—The Imblum Aeronautical Co., 410 West Fourth Street, Pueblo, Colo., plans installation of power equipment in proposed aircraft plant near the Alexander Airport, Colorado Springs, entire project to cost more than $175,000.

D. C., Washington—The American Ice Co., City Center Building, Philadelphia, Pa., will make extensions and improvements in ice-manufacturing plant at Sixteenth and E Streets, N. W., to cost more than $30,000.

Ill., Chicago—The Storkline Furniture Corporation, 4400 West Twenty-sixth Street, is said to be planning the installation of power equipment in proposed new factory unit to cost about $150,000. R. B. Kurzon, 105 West Monroe Street, is architect.

Ill., Evanston—The Board of Local Improvements, City Hall, H. M. Hanford, president, has plans under way for a municipal electric light and power plant, and will soon secure estimates of cost. The city engineer is in charge.

Ind., Indiana Harbor—The Calumet Ice Co., Citizens Trust & Savings Bank Building, is completing plans for a two-story cold storage and refrigerating plant reported to cost close to $75,000, with equipment. G. B. Bright, 2615 Twelfth Street, Detroit, Mich., is engineer.

Ind., New Castle—The Board of Directors, Indiana Village of Epileptics, is considering the construction of a new power house at the State Farm, estimated to cost about $50,000, with equipment

Ind., North Judson—The North American Car Corporation plans installation of power equipment in connection with proposed rebuilding of portion of shops recently destroyed by fire, with loss reported at close to $100,000, including machinery.

Kan., Leavenworth—The Kansas Electric Power Co., Lawrence, Kan., has tentative plans under advisement for the construction of a steam-operated electric generating plant at Leavenworth, reported to cost more than $90,000.

Ky., Jeffersontown—The Continental Lumber & Mfg. Co., Jefferson Building, plans installation of power equipment in proposed plant unit for hardwood production, estimated to cost more than $60,000, with machinery.

Mass., New Bedford—The Firestone Cotton Co., a subsidiary of the Firestone Tire & Rubber Co., Akron, Ohio, plans installation of power equipment in connection with extensions and improvements in mill to cost about $250,000.

Mich., Detroit—The Packard Motor Car Co., 1580 East Grand Boulevard, has filed plans for a one-story addition to its power plant, reported to cost more than $85,000, with equipment. Albert Kahn, Inc., Marquette Building, is architect and engineer.

Minn., Cokato—The Common Council has appointed a committee to secure information and estimates of cost for installation of a municipal electric light and power plant; H. G. Williamson and Richard Peterson are members.

Miss., Laurel—The Masonite Corporation will install power equipment in proposed new addition to local wallboard-manufacturing plant, including high pressure boiler and auxiliaries, entire project to cost more than $75,000.

Neb., Lincoln—The State Capitol Commission is considering the construction of a central power plant for service at new state capitol building and state university, estimated to cost more than $500,000. A legislative appropriation in amount noted is proposed.

N. J., Trenton—The State Board of education plans construction of a power plant at proposed new state normal school at Hillwood Lakes, estimated to cost about $100,000. Entire project will cost approximately $2,000,000.

N. Y., Hastings-on-Hudson—The Hastings Paving Co. plans installation of power equipment in connection with rebuilding of portion of plant destroyed by fire, Nov. 10, with loss reported in excess of $175,000.

N. Y., New York—The Empire State Ice Co., Ninth Avenue and 219th Street, has plans for a new addition to ice-manufacturing and cold storage plant to cost close to $200,000. The Wigton-Abbott Corporation, 552 West Twenty-third Street, is engineer.

Ohio, Cincinnati—The Liberty Ice & Cold Storage Co. has filed plans for a one-story addition to ice and cold storage plant at 1622 Central Avenue, estimated to cost about $40,000. Zettel & Rapp, Cincinnati, are architects.

Ohio, Wilberforce—The Board of Trustees, Wilberforce University, has plans under way for the construction of a one-story power plant at the institution, 50 x 85 ft., to cost about $60,000. H. B. Briggs, Ohio-Hartman Building, Columbus, Ohio, is architect and engineer.

Pa., Allentown—The Board of Trustees, Cedar Crest College, has approved plans for a new boiler plant at the institution reported to cost more than $30,000, with equipment. Jacoby & Everett, Allentown, are architects.

Tenn., Chattanooga—The Tennessee Electric Power Co., Chattanooga, has approved plans for construction of four new power substations and additional transmission lines, reported to cost more than $1,000,000. Stevens & Wood, Inc., 120 Broadway, New York, is engineer.

Texas, Abilene—The West Texas Utilities, Abilene, is reported to be perfecting plans for the construction of a hydro-electric generating plant on Lytle Creek, near Abilene, divided into three units, with entire project to cost more than $3,000,000, with transmission system.

Texas, Houston—The W. D. Haden Co., American National Insurance Building, Galveston, Texas, will install power equipment in proposed new lime plant at Houston, to use oyster shells as raw material, entire project to cost about $130,000.

Va., Mendota—The Mendota Milling & Supply Co., W. B. Vermillion, president, recently organized, is said to be planning construction of new cold storage and refrigerating plant on local site to cost more than $30,000, with machinery.

Wash., Port Angeles—The Washington Pulp & Paper Co., Port Angeles, plans construction of power plant in connection with a proposed new lumber chipping mill for pulp supply at Neah Bay, near the city, entire project to cost more than $80,000. Headquarters are at 534 Battery Street, San Francisco, Calif.

W. Va., Parkersburg—The Parkersburg Corrugated Box Co., Depot Street, will install power equipment in new one-story factory addition, entire project to cost approximately $80,000, with equipment.

W. Va., Parkersburg—The Viscose Co., Marcus Hook, Pa., will install power equipment in connection with proposed addition to rayon mill at Parkersburg, with entire project reported to cost more than $1,000,000.

Wis., Madison—The Board of Regents, University of Wisconsin, has plans nearing completion for a three-story mechanical engineering building at the institution to cost about $575,000, with equipment. C. A. Halbert, Capitol Building, is state engineer.

Wis., Portage—The Portage Co-Operative Food Products Co. plans installation of power equipment in a two-story canning plant to cost about $100,000.

Wis., Sheboygan—The Wisconsin Power & Light Co., Madison, is said to be planning construction of a new steam-operated electric generating plant at Sheboygan, to cost more than $150,000. E. J. Kallevang, Gay Building, is chief engineer.

Wis., West Allis—The Allis-Chalmers Mfg. Co., Sixty-second Street, plans installation of power equipment in a proposed one-story machine works at its mechanical plant, to cost about $300,000.

Wyo., Sunrise—The Colorado Fuel & Iron Co., Pueblo, Colo., plans installation of power equipment in proposed iron ore treating and concentrating mill at its properties at Sunrise, entire project to cost close to $100,000.